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Journal

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Application of Molecular Filter Membranes to Specific Problems in Water Analyses

By Alexander Goetz, R. H. Gilman, and A M Rawn

A paper presented on May 5, 1952, at the Annual Conference, Kansas City, by Alexander Goetz, Assoc. Prof. of Physics, and R. H. Gilman, Project Engr., both of the California Institute of Technology, Pasadena, and A M Rawn, Chief Engr. and General Mgr., Los Angeles County San. Dist., Los Angeles, Calif.

SINCE the first published reports in this country on the use of molecular filter membranes for the bacteriological analysis of water appeared (1–3), the membranes have been recognized as a tool of unique properties in this field and have stimulated a large number of investigations, many of which are still in progress. The specific type of stabilized membranes for hydrosol assay which were developed and subsequently adapted for large-scale production by the authors are now commercially available. These filter membranes consist of homogeneous screenlike, rigid cellulose ester films which are devoid of any fibrous structure, and have a high and uniform porosity of 80 to 90 per cent, and almost complete wet-dry stability. The large number (10^8 per sq cm) of fine pores permits quantitative surface retention of bacterial forms at flow rates of 100 ml per sq cm per min, and subsequent culturing of the retained cells by back-diffusion of one or a sequence of contiguous nutrient media. Concentration of a few microorganisms from large quantities of water—1 l or more—and subsequent separation of the cells from inhibitory environments are thus possible with simple manipulation; ultimately the cultured membrane can be preserved indefinitely as a lacquered leaf.

These advantages are combined with certain limitations, most of which, however, can be overcome by suitably developed techniques and equipment—that is, adaptations to specific problems occurring in water analyses. This paper discusses recent developments and investigations of these techniques and equipment.

Nutrient Schedules

The molecular filter technique permits the separation of the organism from its nutrient by removing the membrane from contact with its nutrient pad and transferring it to another containing a different medium. Clark, Geldreich, Jeter, and Kabler (2) were the first to develop this technique by applying, during the initial phase of incubation—2 to 3 hr—a generally stimulating enrichment nutrient which brings all or general groups of colonies into the logarithmic growth stage. The molecular filter is then transferred to a pad impregnated with selectively inhibitory media which will either retard or inhibit further growth of certain types, or selectively stimulate or fail to inhibit other types.

The specific application of this method to the Endo technique by Clark and Kabler (2, 5) by a two-step nutrient schedule consisted of a stimulating medium applied for the first 2 hr and a specially adapted Endo medium for the remaining 16 hr. It gave a substantially higher recovery of *Esch. coli* and *Aer. aerogenes* forms than the application of the Endo nutrient alone. In extended work, Geldreich and Jeter (6) showed that eosin methylene-blue (EMB) nutrient for the differentiation between *Esch. coli* and *Aer. aerogenes* can also produce satisfactory results. Similar techniques can be applied to the isolation and differentiation of the *Salmonella* group. Table 1 summarizes the procedures developed to date.

TABLE 1

Nutrition Schedules

Purpose	Type Nutrient	Step 1	Step 2	Step 3	Reference
Differentiation of *Esch. coli* and *Aer. aerogenes* from other forms	Endo	Lactose-Peptone Dextrose-Peptone 3 hr at 37 C	Fuchsin Lactose 15 hr at 37 C	—	(2, 4, 5) (8)
Differentiation between *Esch. coli* and *Aer. aerogenes*	EMB	Lactose-Peptone 2 hr at 35 C	EMB + Bile Lactose 16 hr at 45 C	—	(6)
S. typhosa	Wilson Blair	BG + $Bi_2(SO_3)_3$ 30 hr at 35 C	—	—	(6)
Differentiation among *Salmonella* species		Tetrathionate 3 hr at 35 C	Brilliant green broth 16 hr at 35 C	Urea Thymol-blue 15–20 min	(6)

Although this method promises numerous applications for specific purposes, it has, for large-scale routine operation, the disadvantage of requiring an additional manipulation of the molecular filter because of the transfer from one pad to another. This transfer involves exposure of the culture and may cause severe growth retardation, accidental contamination and partial dry-out, if not expertly handled.

Efforts have been made to overcome the additional manipulation by using a

preimpregnated, dehydrated, scheduled nutrient pad which consists of two components—a thin leaf of a porous paper (*A*, Fig. 1) and a heavier disk of blotting paper (*B*, Fig. 1). The leaf (*A*) is impregnated with a required quantity of a generally or partially stimulating nutrient, whereas the pad (*B*) is impregnated with the inhibitory or second nutrient. Both *A*

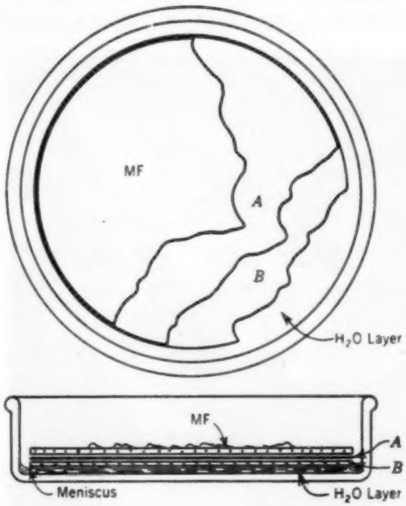

Fig. 1. Molecular Filter (MF) With Preimpregnated, Dehydrated, Scheduled Nutrient Pad

The nutrient pad consists of two parts—a thin leaf of porous paper, A, *which is impregnated with a required quantity of a generally or partially stimulating nutrient; and a heavier disk of blotting paper,* B, *which is impregnated with the inhibitory or second nutrient.*

and *B* are subsequently dehydrated, and are then attached to each other to form one unit. The leaf *A* has the property of selectively removing the inhibitory dye from *B* until *A* is saturated. The insertion of this pad into a dish which carries the required quantity (2.3 ml) of sterile water will first rehydrate the nutrient in *B* and bring this nutrient into *A*, from which it is gradually lifted to the molecular filter surface by the capillary forces of the membrane. When the *B* solution passes initially into *A*, the dye in the solution will be removed by *A* while it will be enriched by the addition of the dissolved medium in *A*. As this *A-B* mixture is metabolized on the molecular filter surface, more *B* will pass through and will carry gradually increasing dye concentrations to the membrane as *A* becomes saturated. Finally, the *B* solution will enter *A* in its original composition. The microorganisms on top of the molecular filter will therefore be reached in the initial growth phases by an enrichment nutrient which will gradually change its composition. The rate of transition from *A* into *B* can be controlled in various ways, too complex for detailed description.

The use of the preimpregnated, dehydrated, scheduled nutrient pad will effect two economies: [1] the operating laboratory does not have to prepare nutrients; and [2] a timed nutrient schedule which is accurately reproducible can be automatically maintained provided that the main factor which controls the diffusion rate—that is, the incubation temperature—is closely maintained. It may be mentioned that there are other ways in which a timed reaction and change between even more than two nutrients can be accomplished.

The method of scheduled nutrients has thus far been specifically applied to an Endo type nutrient in which the basic fuchsin is the inhibitory element that is absorbed in the early stages by the leaf, *A*. Similar applicability is

indicated in EMB nutrient (removal of eosin and methylene blue).

Ocean Water Testing

To determine the practicability of utilizing the foregoing technique in the field, especially under adverse conditions, the membrane filter was used in conjunction with an existing bacteriological survey. For the last eighteen years the sanitation districts of Los Angeles County, Calif., have been making weekly bacteriological surveys of the littoral waters near the districts' sewage outfall which extends into the Pacific Ocean from a promontory known as White's Point. Until recently these tests were made using standard procedures involving serial dilution testing with lactose broth fermentation.

Early in 1952 the offshore testing was expanded to include parallel tests with the molecular filter membrane. In instituting this procedure, several objectives were set forth: [1] to determine the relationship between *Esch. coli-Aer. aerogenes* counts obtained on the molecular filter as compared with the most probable number (MPN) indicated by standard procedures; [2] to determine the performance of the molecular filter in the presence of the multitude of microflora and microfauna which abound in the ocean; [3] to determine the effect of various media and their scheduled application to the filter membrane upon the growth of coliform organisms in the presence of ocean microorganisms; and [4] to determine the relative amounts of time consumed in the use of standard procedures as compared with the molecular filter membrane technique.

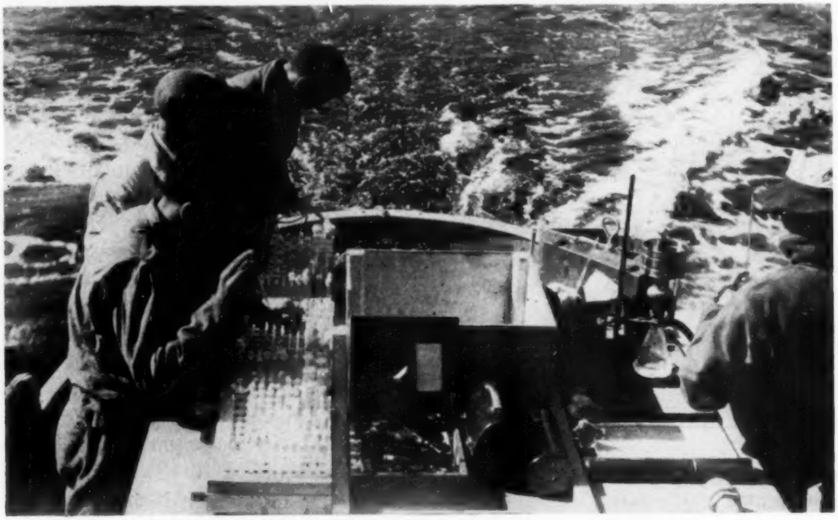

Fig. 2. Bacteriological Surveys of Ocean Waters

Lactose broth serial dilution testing is being conducted at the left, molecular filter testing at the right.

The results obtained from three months of field testing demonstrate the feasibility of using molecular filter membranes for ocean surveys. The

tests show a greater consistency and accuracy than can be achieved by standard procedures with two sets of four decimal dilutions in lactose broth.

The data do not indicate a perfect agreement between molecular filter counts and MPN. This lack of agreement is not unexpected when it is realized that the lactose fermentation tests using five decimal dilutions with five parallel tubes may result in deviations from the true count for any one sample ranging between 70 per cent less to as much as 260 per cent more.* As all tests were conducted with only two parallel tubes in four-decimal dilution steps, there is a corresponding increase of uncertainty in the MPN value.

These tests involved two different methods of incubation and the use of Endo medium in three different forms of application. As incubation on the boat was inconvenient, a large proportion of the tests was run by placing the molecular filter in contact with the nutrient immediately after filtration, but leaving the dish at outdoor temperature (60 to 80 F) until return to the laboratory (3 to 7 hr) where the dishes were transferred to the incubator (98 F) until the next morning (16 hr). Later, an improvised incubator was available on the boat and parallel tests on the same sample with, and without, initial incubation could be run. An evaluation of this effect on the molecular filter cultures was considered significant for field tests in general, and particularly for marine tests, inasmuch as prolonged exposure to low temperature permits competitive development of the marine flora in the initial phases. Figure 2 shows a bacteriological survey being conducted on the boat.

TABLE 2

Performance of Various Molecular Filter Nutrients

Nutrient	Delayed Incubation			Immediate Incubation		
	Performance	No. of Tests	Disagreement*	Performance	No. of Tests	Disagreement*
Endo only	Poor	67	12	Poor	0	0
Endo plus enrichment	Poor for high counts Fair for low counts	79	4	Fair for high counts Good for low counts	21	0
Dehydrated Endo schedule	Good for low and high counts	9	0	Good for low and high counts	9	0

* The number of tests which disagree with the MPN indication for the permissible sanitary limit of 10 organisms per ml.

Endo medium, in the form developed for the molecular filter technique (5, 6), was applied either directly or after an enrichment nutrient was in contact with the molecular filter for 2 to 3 hr for immediate, or 3 to 7 hr for delayed, incubation. Finally, a nutrient schedule in dehydrated form, as described previously, was applied.

Table 2 presents procedures used and the performance for each combination. Obviously the Endo nutrient used alone offers no promise, whereas the Endo nutrient plus enrichment and

* Woodward (9) has demonstrated by extended experimentation on polluted natural waters that the average coefficient of variation of a thirty-tube MPN determination approximates that of one membrane count.

the dehydrated Endo schedule appear reliable as qualitative indicators. Table 3 demonstrates the degree of general quantitative reliability of the Endo nutrient plus enrichment and the dehydrated Endo schedule. A typical selection of actual counts with sheen on the molecular filters and the corresponding MPN values is given.

TABLE 3

MF Counts and MPN on Different Nutrients

MPN	Endo Plus Enrichment		Dehydrated Endo Schedule	
	Delayed Incubation	Immediate Incubation	Delayed Incubation	Immediate Incubation
700	88 51	188 240	239 149	218 176
240	220 (290*)	154 (187*)	—	—
70	0 (10*) 3 (9*)	10 (10*) 49 (81*)	— —	— —
62	53 51	42 47	56 95	48 1 (?*)
24	15 (18*) — 1	15 (24*) 2 7	45 (52*) 12 27	26 (71*) 10 (12*) 22
6	2	23	6	(?)
−3.1	2	1	1	0

* Number of colonies with questionable sheen.

As the achievement of an exact numerical relationship for a limited number of samples with MPN would be purely accidental, the counts for the Endo nutrient plus enrichment with immediate incubation, and the dehydrated Endo schedule with both delayed and immediate incubation should be considered satisfactory for counts not exceeding 220.

The results available to date establish that:

1. The molecular filter on Endo plus enrichment nutrient yields entirely reliable information, in agreement with MPN, when 10-ml samples are used for a limit of 10 organisms per ml.

2. The qualitative indication is not impaired by delayed incubation.

3. Quantitative agreement on wet and dehydrated Endo nutrient schedules of molecular filter counts with MPN—within statistical limits—can be expected for counts less than 220 for immediate incubation; for delayed incubation, the dehydrated Endo schedule appears to be more reliable.

4. The dehydrated Endo schedule appears to perform as well, or better than, the liquid nutrient application.

The molecular filter count on an Endo medium and the MPN derived from the lactose fermentation yield the total count of the *Esch. coli-Aer. aerogenes* group, but it is desirable to be able to differentiate between the two types. The littoral waters of the ocean are often profuse with *Aer. aerogenes* bacteria coming from the soil of the shoreline, particularly after periods of heavy rainfall when surface runoff from the land carries these organisms into the surf. Ocean surveys conducted during these periods with standard lactose fermentation tests indicate a degree of sewage pollution which does not exist. *Aerobacter aerogenes* is generally not of sewage origin, unless the sewerage system is designed to carry storm waters, a common practice in many Eastern cities. Thus, *Aer. aerogenes* and intermediates, trapped in the sampling process, will yield results in the lactose fermentation tests which are grossly misleading. Procedures for confirming the presence of *Esch. coli* are time-consuming and cannot be used in practice without increasing the laboratory testing far in excess of that required for simple determination of MPN. The application of a nutrient schedule of the EMB type will be particularly useful in investigations of this kind.

An interesting observation in the ocean surveys was the discovery that no sterilization of the funnel or membrane-holding device was required to yield consistent results. Sterilization of the equipment between tests was therefore unnecessary.

Perhaps one of the most striking advantages of the membrane filter technique is the amount of time saved over that required for normal lactose broth, serial dilution testing. The savings in glassware and nutrients are appreciable, but are outweighed by the savings in labor. The time consumed in various operations is tabulated in Table 4 and indicates the relative economic merits of the two systems when compared on a labor-use basis.

TABLE 4

Laboratory Hours Required for One 8-Hr Ocean Survey

Lactose Broth Fermentation*	Time Required *hr*	Molecular Filter Membrane	Time Required *hr*
Preparation of media, preparation and sterilization of tubes	5	Preparation and sterilization of media	$\frac{3}{4}$
Preparation of pipets and supplemental equipment	2	Preparation of pipets and Petri dishes	2
Reading tubes, transferring inoculations, washing tubes	$7\frac{1}{2}$	Reading molecular filter counts, washing Petri dishes	1
Total	$14\frac{1}{2}$	Total	$3\frac{3}{4}$

* Includes time required for confirmatory tests.

Table 5 gives a list of sterile glassware required for each MPN determination by two parallel four-step dilutions and confirmation and for two parallel molecular filter tests on a liquid and dehydrated nutrient schedule.

Even though the sampling time for both procedures was assumed to be the same and the only time savings existed in the laboratory, an additional advantage is the quick, simple operation of the molecular filter as contrasted with the more delicate and time-consuming technique of the lactose broth fermentation tests. When the time required for setting each sample is at a premium, the advantages are even greater.

Suspended Solids

The retention and flow characteristics of the molecular filter membrane suggest its possible use for other than bacteriological tests. The applicability of the molecular filter to the physical examination of water, especially the determination of suspended solids—possibly the most elementary, nonbiological test—has been the subject of a systematic investigation at the California Institute of Technology. Although not yet complete, the information available at present merits description.

The accepted standard method for the determination of suspended solids in sewage or water is based on the use of the Gooch crucible (7). A filtering mat is formed in the bottom of the crucible from a slurry of asbestos fibers, the crucible is dried and weighed, a known quantity of the water sample is filtered through, and after again drying and weighing, the mass of the particulate matter retained by the mat is determined.

In order to compare the efficiency of the crucible and molecular filter methods in retaining suspended matter, precautions were taken to insure the identity of comparative samples. Suspensions of various amounts of uniform diatomaceous earth varying from 25 to 800 ppm by weight were prepared. Sixteen 100-ml samples from each such stock were passed through either a Gooch crucible or a molecular filter membrane. A commercial diatomaceous earth,* was chosen which is calcined at 1,800 F and of which 80 per cent of the particles are between 1 and 6 μ.

TABLE 5

Equipment Required for MPN and Molecular Filter Determinations

Sterile Equipment	MPN	Molecular Filter	
		Liquid	Dehydrated
Number of Items			
Prepared nutrients	2	2	0*
Tubes	20–22	2	0
Pipets	10	2	0
Dishes	2–4	4	2
Total	34–36	10	2*
Time required for information—*hr*	72	16–18	16–18

* One buret with sterile water is required for rehydration for every 50 to 100 molecular filter tests.

The determination of the suspended solids with the Gooch crucibles was performed in accordance with the latest edition of *Standard Methods for the Examination of Water and Sewage* (7). The determination with the molecular filters was made in an analogous manner, each membrane being dried and tared before use, then dried and weighed after filtration. The filtering of each sample of water through a molecular filter was performed in the same manner as the bacteriological tests are made (3) without, however, requiring sterile conditions.

A comparison of the results of these determinations of suspended solids by the two methods is shown in Fig. 3. A logarithmic scale for the suspended solids (abscissa) was chosen in order to parallel the subjective turbidity standard. The curve shows that the Gooch crucible retained less of the suspended matter in the samples than the filter membrane. The approaching coincidence at approximately 800 ppm can be explained by the formation of a heavy filter cake on the pad of the Gooch crucible which makes a closely quantitative retention of the particles possible. The figure also shows that the filter membrane retained significantly more particles in the range below 100 ppm—the range that is probably most interesting to water works engineers.

The conditions of these tests were fixed arbitrarily to assure optimum performance of the Gooch crucibles. These conditions are not necessarily the optimum for the molecular filters. Greater effectiveness of the filters, especially with waters containing relatively low concentrations of suspended matters, could easily be gained by using larger samples. Only the eventual clogging of the pores of the molecular filter or the building-up of a filter cake causing a decreased flow rate should limit the volume of the water sample passed. The use of larger-sized water samples with consequent larger amounts of suspended matter would tend to decrease the relative errors inherent in weighing small quantities on a laboratory balance.

* No. 505, a product of Johns-Manville, New York.

The quantity of light both scattered and absorbed by particulate matter in a water column can be empirically related to the concentration of suspended solids. In these experiments, turbidity measurements, according to standard methods, were taken of all samples tested by the Gooch crucible and molecular filter membranes. The relations between turbidity and suspended solids, as determined by each of the two methods, were similar and analogous throughout the range. The absolute relationship between turbidity and suspended solids—that is, between optical properties and mass of suspended solids of a water sample—is complex. The optical turbidity test is more sensitive with waters with low concentrations of suspended matter. Additional investigations with molecular filters are planned in the region of low turbidity to evaluate the merits of both methods in the range below 50 ppm.

As the molecular filters require no preparation prior to use in determining suspended solids, they have an advantage in laboratory use over Gooch crucibles which require the pouring of an asbestos pad. Although the molecular filters used in this investigation were dried in a desiccator before the initial weighing, other studies show that the mass variations of suitable molecular filters are of the magnitude of 5 mg and that the amount of moisture they will absorb can be reduced to nothing by hydrophobic conditioning. Thus it may be assumed that for the usual routine determinations of suspended solids, molecular filter membranes may be used as packaged, omitting initial drying and weighing. They may be subsequently dried in either an oven or a desiccator.

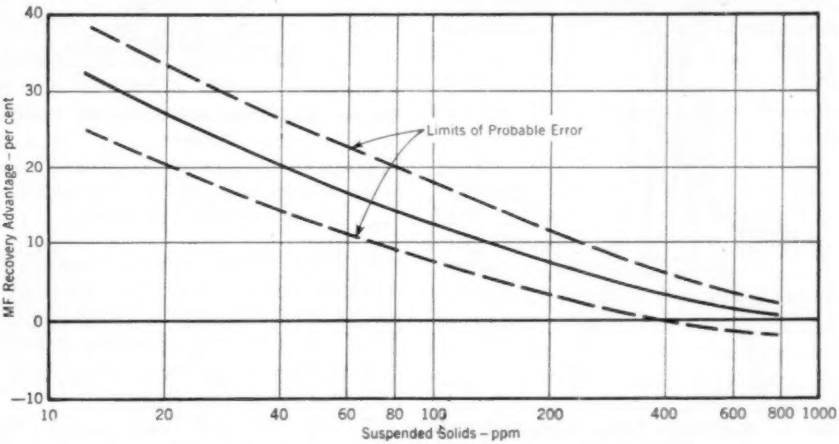

Fig. 3. Advantage of Suspended Matter Recovery by Molecular Filter

The solid line indicates the recovery advantage offered by the molecular filter over the Gooch crucible. The limits of probable error are indicated by the broken lines.

Sterilization Technique

Extended laboratory and field use have proved the filtration equipment for water tests (hydrosol unit) previously described (1, 2) sufficiently reliable to warrant no alteration other

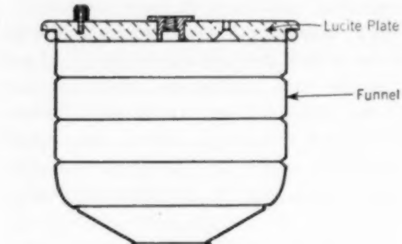

Fig. 4. Assembled Filter Equipment and Filter Flask

The original equipment has been altered by the addition of the lucite plate which fits into the aperture of the funnel and protects the filtrate against contamination during filtration.

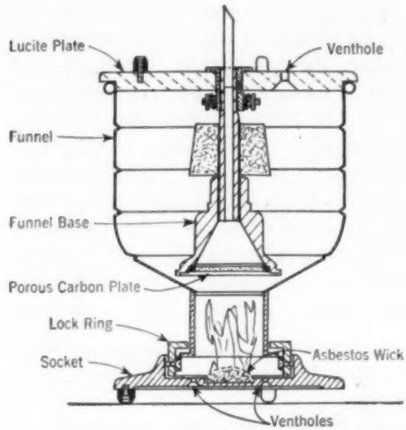

Fig. 5. Apparatus Assembled for Sterilization

The base of the apparatus is screwed from below into the plate and hangs freely suspended within the funnel.

than the addition of a graduated and seamless stainless steel funnel. This funnel minimizes adhering residues of water samples and, thus, the contamination of a test by the preceding test.

Extended experiments have shown that, for most operations, intermediate sterilization of the equipment is not required. When highly polluted samples, such as sewage, alternate with samples of pure water, however, the necessity for sterilizing the equipment is evident. Using customary autoclave methods which, with the necessary preparations, require in most laboratories 1 to 2 hr, a large number of units may be necessary, representing objectionable bulk and investment.

This difficulty has been overcome by a development which does not involve a change in design of the unit, but only the addition of one part. The sterilizing agent is formaldehyde which is formed in the apparatus along with carbon dioxide, water, and formic acid by incomplete combustion of methyl alcohol ($2CH_3OH + O_2 \rightarrow 2HCOH + 2H_2O$). The formaldehyde sterilizes all parts of the filter equipment and all the inner parts of the funnel.

Figure 4 shows the filter equipment assembled on top of a filter flask in the manner described previously (1, 3) with only minor alterations. One alteration is the addition of a lucite plate which fits into the aperture of the funnel in order to protect the filtrate, during fil-

tration, against contamination. In the center this plate carries a fitting with female thread. During filtration this opening acts as a vent.

After the filtration is completed, the base is screwed from below into the plate in the manner shown in Fig. 5. As the figure shows, the dimensions of the various parts are such that the base hangs freely suspended in vertical position within the funnel. The new part designed for the sterilization procedure is a socket which carries a recess in the center into which the lock ring fits. In this position, all formerly exposed parts of the funnel base are suspended freely. In the center the socket carries, in a recess, a circular asbestos wick held in position by a screen and surrounded by a set of ventholes.

To sterilize the apparatus a few milliliters of methyl alcohol are poured onto the wick which is then lighted with a match. The funnel is put in position and the flame is allowed to burn for approximately 10 sec. During this time, the air volume in the funnel is heated so that a draft of fresh air is created through the ventholes in the socket. Then the plate with the suspended base is slowly inserted into its fit on the funnel. No further attention is necessary as, for a few seconds more, the flame burns assisted by the ventholes in the plate, but as the draft diminishes, the combustion becomes less complete and produces, instead of carbon dioxide and water, to an increasing extent, formaldehyde with traces of formic acid and water. The flame is extinguished when no more additional oxygen is available—that is, when no more oxygen can be brought in from outside. The assembly is allowed to remain in this position until used.

The performance of the sterilizing equipment was tested by filling the assembled apparatus (Fig. 4) with 400 ml of water containing an artificial bacterial contamination of approximately 10^5 per ml *Esch. coli,* 10^4 per ml *B. subtilis* (*globigii,* spores), and 10^5 per ml *Staph. aureus.* After the liquid has passed through the equipment—funnel, carbon screen, and base—the unit was disassembled and sterilized in the position shown in Fig. 5. After an elapsed time varying between 10 and 30 min, the unit was reassembled for filtration, a molecular filter membrane was inserted, and 50 to 100 ml of sterile water were filtered through the membrane after first wetting the interior with the sterile water. Subsequently the membranes were cultured. The control experiment followed the same procedure without performing the sterilizing procedure.

It is obvious that if a drop of the contaminated fluid remains after the first filtration, it affects the time required for the sterilization process. If these drops are removed before sterilizing by wiping with a paper towel or by rinsing with tap water, the reduction of the remaining contaminants is more rapid as the following data show:

After 10 min exposure, the wiped equipment showed four colonies which were reduced to one after 15 min, and none after 30 min. The nonwiped equipment showed fifteen colonies after 20 min and none after 30 min. The controls showed, in the wiped equipment, 1 to 2×10^3 and in the nonwiped, 2 to 3×10^3 colonies.

In order to test for an inhibitory residue, a membrane was inserted immediately after the sterilization procedure and through it was filtered a *Staph. aureus* suspension of known concentration. The results were com-

pared with an analogous passage through a unit which had not been exposed previously to formaldehyde. The concentration on the membrane was of the order of 10^3 to 10^4 organisms. No difference between the two samples could be demonstrated and it can therefore be assumed that an inhibitory residue is absent.

For most purposes, an exposure to the sterilizing procedure of 15 to 30 min, even in the presence of heavy (spore-containing) contaminants, appears sufficient, especially if either rinsing or wiping is used to remove the liquid residues of the preceding filtration. The procedure is designed for easy aseptic manipulation. Only approximately ½ min is required to put the unit in operating condition.

Formaldehyde produced in the unit in high concentrations from methyl alcohol appears to have considerable advantage over ethylene oxide required for the sterilization of the molecular filter leaf and the nutrient pads, partly because of the absence of a fire hazard, but mainly because of the high volatility of formaldehyde, which seems to avoid a subsequently inhibitory residue on the walls and the base of the equipment.

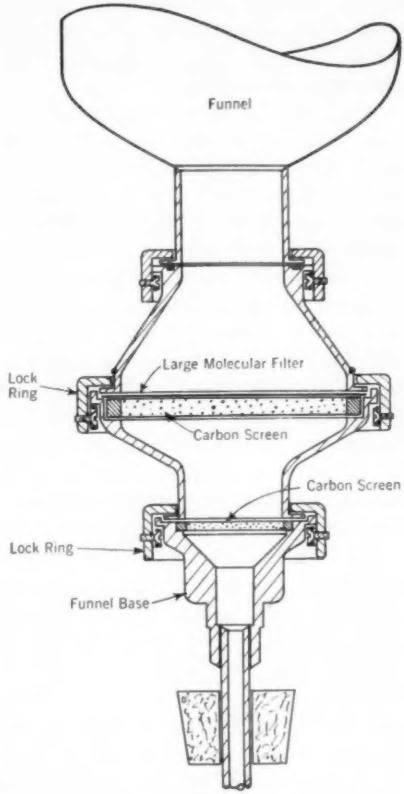

Fig. 6. Molecular Filter With Filter Area of 50 sq cm

The large molecular filter was designed to reduce the density of the clay, algae, or aluminum floc layer in waters having a high concentration of suspended matter.

Filter Enlargement

A new modification of the filter equipment has been designed to overcome the initially mentioned limitations of the molecular filter techniques. Several authors (2, 3) have found that the molecular filter is applicable only to a limited extent in sanitary tests of raw water supplies with high concentrations of suspended matter such as algae, clay, and aluminum floc. The basic disadvantage arises from the retention by the molecular filter surface of the major part of the nonbacterial suspended matter as a surface deposit, within which the microorganisms are imbedded. This layer can produce serious deviations from normal growth habits and render the organisms either indistinguishable or inhibit the proper development of the characteristic reactions, such as the development of a sheen by certain organisms when an Endo medium is used.

One way to avoid this heavy layer is the reduction of the volume of the sample to a quantity which does not deposit sufficient suspended matter on the molecular filter surface to interfere with the bacterial growth. As Streicher and Neumann (3) have pointed out, this volume reduction would restrict the application of the molecular filter to tests on untreated waters that carry fairly large bacterial contaminants.

The difficulty can be overcome, however, by using a larger molecular filter disk with a filter area of 50 sq cm, as shown in Fig. 6. A carbon screen designed to hold a molecular filter 9 cm in diameter can be inserted in the standard filter unit previously described. The molecular filter is clamped on the carbon screen by a lock ring. The 9-cm size was chosen as the membrane can be inserted into the standard Petri dish, 9 cm in diameter, on an accordingly larger nutrient pad. Hence, a 100-ml sample produces a clay layer having only one-fifth the density of the normal filter size, thus increasing the reliability of the count by a factor of five.

Acknowledgments

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Control of Boiler Feedwater and Cooling Water

By S. M. Paradiso

A paper presented on Feb. 14, 1952, at the Indiana Section Meeting, Indianapolis, by S. M. Paradiso, Power Plant Engr., Eli Lilly & Co., Indianapolis, Ind.

INDUSTRY requires that waters used for boiler feed do not form scale, cause corrosion, "carry-over," or cause caustic embrittlement. Waters that meet these requirements are essential to the economical production of steam, the protection of costly equipment, and the minimizing of maintenance.

A water that is not scale-forming will not precipitate minerals that would adhere to the boiler wall and reduce the heat transfer from the hot gas to the water. Such a reduction in rate of heat transfer would not only result in loss of heat to the flue gases, with consequent reduction of efficiency, but might also cause excessive increase in the temperature of the boiler metal.

The water temperature in a boiler is determined by the pressure at which it operates. At 100 psi of pressure, the temperature is 328 F; at 200 psi, 382 F; and at 400 psi, 444 F. As the water temperature cannot decrease, the metal temperature must increase. The practical temperature limit of boiler steel currently used is approximately 900 F. If the scale is thick enough, the metal temperature may exceed this limit, and a failure will result. In extremely high-pressure boiler work, a scale thickness of 0.010 in. is sufficient to cause a failure.

Noncorrosive water is water that will not destroy metal. In general, there is little trouble with corrosion in the boiler itself, but if steam is returned as corrosive condensate, condensate lines can be severely damaged.

Water that will not carry over is water that has no solids which can be entrained in the steam bubbles and pass out of the boiler with the steam. If solids are carried over, they deposit on valves, piping, and turbine blades. A heavy deposit on turbine blades can reduce the efficiency of the turbine and may even cause an unbalance that can destroy the machine.

Caustic embrittlement is similar to corrosion, but acts in the boiler and causes intercrystalline cracking of the metal. This condition will develop more readily on riveted joints and small cracks such as those around the tube holes or around a leaking manhead. If not checked, it can cause complete failure of the boiler. The present approach to the problem consists of maintaining a certain ratio of sulfate to carbonate, depending on the operating pressure of the boiler. A new approach—the maintenance of simultaneous control of the pH and phosphate content—has been suggested.

Treatment

The first step in conditioning the water to meet specifications is to ascertain what the supply water contains. The author's company either analyzes the water in its laboratories or has it analyzed outside the plant. The analysis determines the quantity and number of the following gases and dissolved solids:

1. Carbon dioxide—chief cause of acid corrosion and low pH.
2. Oxygen—cause of corrosion and pitting.
3. Calcium and magnesium salts (CO_3, HCO_3, SO_4, and Cl_2)—chief causes of boiler scale.
4. Silica—cause of hard, porcelain-like scale in boiler and deposit on turbine blades if carried over.
5. Iron—cause of deposits in boiler.
6. Sodium salts (all very soluble and incapable of removal by precipitation) —all except sodium chloride impart alkalinity to boiler water and can cause foaming in boiler.

The second step in the treatment of boiler feedwater may be broken into two broad classifications—external and internal treatment. In external treatment, an attempt is made to rid the water of the undesired substances before it reaches the boiler. In internal treatment, the idea is to prevent the non-soluble scale-formers from adhering to the boiler metal. In addition, external and internal treatment may be combined.

There is no cure-all. Each and every water and condition must be analyzed and the treatment worked out on the basis of the analysis. Salesmen frequently say they have a treatment that will solve all problems and also save money—all with no knowledge of the problems and costs. These cure-all claims are unfounded.

Many interesting remedies have been propounded. It has been claimed that a glass tube containing a little mercury and some rare gases would end all feedwater troubles simply by allowing the feedwater to run over the tube. Another cure consisted of installing in the feedwater line two electrodes which, when energized, would prevent scale, sludge, and corrosion. How? No one knows. It is a fact, however, that a change in saline content, even a complete cessation of treatment, will sometimes remove old scale. This fact, of course, would seem to prove the claims of the quack remedies. The scale soon reappears, however, and the problems are worse than ever. These examples should not be confused with legitimate electrical devices for cathodic protection.

The legitimate external systems for feed water treatment include:

1. Sodium cation exchanger (zeolite) process
2. Hot lime-soda process
3. Cold lime-soda process
4. Hydrogen, or acid-cycle cation exchanger
5. Demineralization
6. Distillation
7. Combination of lime and sodium cation exchanger.

Sodium Cation Exchange

The sodium cation exchanger process is one of the simplest and easiest to operate. It is also the most familiar process as the majority of home softeners are of this type. The original material was a greensand zeolite, but synthetic resins, which have greater exchange capacities, are now avail-

able. The greensand zeolite is a substance termed Na_2Z, as it is composed of the cation Na_2 and the anion "Z," a complex zeolite molecule. The reaction that takes place is fundamentally an exchange of the Na for the Ca or Mg cation, the scale-forming ions.

$$Ca^{++} + Na_2Z \rightarrow CaZ + 2Na^{++}$$
$$Mg^{++} + Na_2Z \rightarrow MgZ + 2Na^{++}$$

The greensand zeolite has a capacity, depending on the grade, of 3,000 to 5,000 grains per cubic foot. After the reaction has proceeded to the point at which the zeolite will not release any more sodium in exchange for calcium or magnesium, it is necessary to replace the sodium ion by washing the material with strong brine (sodium chloride solution). The action is now reversed:

$$CaZ + 2NaCl \rightarrow CaCl_2 + Na_2Z$$

The calcium chloride is run to waste.

The synthetic resins have capacities ranging up to 30,000 grains per cu ft, although it is more economical to use them only for 20,000 gr per cu ft, as the more conservative figure requires only 0.3 lb of salt for regeneration, instead of 0.5 lb. The synthetic resins of the sodium alumino-silicate type may transfer silica to waters that are low in silica content, but there are other synthetic resins that do not contain silica.

In general, the synthetic resins are used for waters of high hardness if a small unit is required. Greensand zeolite is more commonly used for low hardness waters. Sodium cation exchangers, however, will not cure all troubles. They should not be used in waters of low or high pH, which are harmful to them, and they should not be used on turbid waters, as these waters will clog the exchanger rapidly. A turbidity of less than 10 ppm is best. The advantages of sodium cation exchange for boiler feed conditioning are that the treatment removes all the hardness—although some scale will still form, however, and internal treatment should be used—and the concentration of suspended solids will be very low. The principal disadvantages are those listed below:

1. There is no reduction in alkalinity or total solids.
2. All the alkalinity concentrates in the boiler and a high rate of blowdown is required to control it.
3. High alkalinities are objectionable as they tend to promote both carryover and caustic embrittlement.
4. Waters softened by this method tend to be corrosive.

Hydrogen Ion Exchangers

Hydrogen ion exchangers are natural and synthetic nonsiliceous materials which, when operated on the hydrogen or acid cycle, will exchange hydrogen for cations such as magnesium, calcium, and sodium. When the compound is exhausted it is regenerated with acid. Sulfuric acid is generally used for economy. The nonsiliceous and carbonaceous materials may also be used in the sodium cycle. Typical reactions are:

$$\begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix}(HCO_3)_2 + H_2Z \rightarrow \begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix}Z + 2H_2CO_3$$

$$\begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix}SO_4 + H_2Z \rightarrow \begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix}Z + H_2SO_4$$

$$\begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix} Cl_2 + H_2Z \rightarrow \begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix} Z + 2HCl$$

The exhausted compound is regenerated with sulfuric acid:

$$\begin{bmatrix} Ca \\ Mg \\ Sa \end{bmatrix} Z + H_2SO_4 \rightarrow H_2Z + \begin{bmatrix} Ca \\ Mg \\ Na \end{bmatrix} SO_4$$

The sulfates are discharged to waste.

All bicarbonates are converted to carbonic acid which, being unstable, can easily be removed by deaeration or degasification. All the hardness is removed, bicarbonate alkalinity is removed, and the solids are reduced. Other acids are not as unstable, however, and the water must be neutralized to prevent severe corrosion. Three ways to neutralize the acids are:

1. Use of split streams—sodium and hydrogen ion exchangers operating in parallel
2. Alkali neutralization—caustic soda–soda ash
3. Raw water neutralization—water that is low in total hardness and high in sodium bicarbonate alkalinity.

Demineralization

Demineralization is similar to the cation exchange method. The cations are removed by hydrogen exchange and the anions by an anion exchanger regenerated with an alkali. The effluent is comparable to distilled water. The chief disadvantages of this system for boiler feedwater are the nonremoval of silica and the fact that the temperature must be maintained at less than 100 F.

Lime-Soda Process

The other basic method of boiler water treatment is the lime-soda process, either hot or cold. In general, the cold process may be eliminated. The hot lime-soda process is probably the most widely used process in boiler plants of any size that use hard water and have a high percentage of make-up. Hydrated lime and soda ash are the principal chemicals used. Phosphate is used in the treated and settled effluent to achieve further hardness reduction. The hot lime-soda process requires: [1] chemical feeders, usually of the proportioning type with a constant mechanical agitator; [2] heater and treatment and settling tank; [3] filters; and [4] storage tank.

The heater is a large tank in which, by various means, the chemicals are added to the raw water which is heated with steam at about 5-psi pressure. The raw water coming in is passed through a vent condenser, and the dissolved gases are flashed to the atmosphere. Lime, either CaO in the unslaked form or $Ca(OH)_2$ in the hydrated form, reacts with the soluble bicarbonates to form the insoluble carbonates:

$$Ca(HCO_3)_2 + CaO \rightarrow 2CaCO_3 + H_2O$$

The soda ash reacts with the noncarbonate hardness, SO_4 and Cl, to produce highly soluble salts and nonsoluble carbonate.

The tanks are designed to have a retention time of approximately an hour and are baffled so that the flow is downward and then upward in order that solids may settle and be blown off as sludge. The effluent then passes upward and is pumped to clarifying filters and then transferred to the storage tank from which it is pumped into the boilers. Phosphate, when used, is fed directly to the boiler drums from a separate feeder, as it would otherwise react

with the lime and form an insoluble calcium phosphate.

The filters usually contain anthracite coal to prevent the addition of silica. Usually two or more are in a battery so that one can be kept in service while the other is being backwashed.

The sludge blanket type of hot lime-soda softener allows effluent to come up through the sludge, primarily for silica removal. Magnesia is the chemical added in this treatment. The design varies with the amount of makeup and condensate return and the desired reduction of dissolved oxygen.

Lime-Zeolite System

The lime-zeolite system is a combination of the hot lime-soda and sodium cation exchange systems. The effluent from the hot lime-soda filter is passed through the sodium-cycle cation exchanger. In the hot lime-soda softener the great mass of bicarbonate hardness is removed, the alkalinity and solids are reduced to nearly the same extent, and the silica removal is efficiently carried out. When the water from the hot lime-soda system passes through the zeolite softener, the effluent is completely soft, and the phosphate requirements are reduced.

Internal Treatment

It has been said that in 1820, a sack of potatoes was put into a boiler to cook, and, by some mischance, was forgotten when the boiler was closed and put on the line. When this boiler was subsequently taken off the line, it was found that the scale was softer and easier to remove, and that there was less of it, as much of it had come down as sludge. For many years engineers used to throw a few potatoes into the boiler after every cleaning, and this practice was the beginning of internal treatment of boiler water. The potatoes did not reduce the total amount of deposits, but the starch reduced the deposits on the metal, and made the deposit soft and allowed them to be blown out with the sludge. The use of potatoes was later superseded by that of starch and then tannins, lignins, and other organic and inorganic materials.

External treatments have as their object the reduction in calcium and magnesium content of the water. Internal chemical treatment is used to prevent deposits and scale formations from the residual hardness left in the feedwater, and also to keep boiler surfaces clean where no external treatment is used.

Present-day internal chemical treatment uses commercial chemicals to accomplish certain specific objectives. The principal object of internal treatment is to precipitate the calcium and magnesium salts as a sludge and to maintain this sludge in a fluid form so it may easily be removed in the blowdown.

The most common chemicals used in internal treatment are the sodium phosphates—monosodium, disodium, and trisodium phosphate and sodium metaphosphate. Upon entering the boiler, all of these phosphates change to the trisodium form and react with calcium to form the flocculent tricalcium phosphate, at a pH of 9.5 or higher. The choice of the phosphate depends on economics and the alkalinity of the boiler water. Sodium monophosphate and metaphosphate are acid and tend to reduce the alkalinity. Trisodium phosphate is alkaline and develops alkalinity whereas disodium phosphate is more neutral. The sludge is maintained in a liquid form by applying organics, such as tannins, lignins, and

starches. It is often desirable to use both external and internal treatment, but each application requires a study of its own as no firm and fast rule can be made.

Control

Another factor in boiler feedwater treatment is control. Too often, especially in a smaller plant, the water is analyzed by trained people and the proper treatment is installed, but no control measures are instituted. Conditions later change, with the result that the treatment that was right yesterday may mean over- or undertreatment today. Both the feed and boiler water must be analyzed periodically and the treatment adjusted to the condition.

The sample for analysis should be taken through a cooling coil. If water is drawn directly out of a boiler operating at 200 psi of pressure, the water temperature will be approximately 400 F, and the vapor will escape. The sample will thus contain proportionately more solids than actually exist in the boiler water. The sample should be taken in a glass container which is clean and which has been rinsed several times.

The frequency of testing depends on the prevailing conditions. Normally once every 8 hr should be sufficient. If conditions are erratic, more samples should be taken. Whenever a change is made in the treatment, time must be allowed for it to take effect before another sample is taken. Records should be kept of all tests and chemical feeds, and these records should be studied so that recurrences of possible troubles can be foreseen and the proper action to avoid them taken.

Cooling Water

Another of the many uses of industrial water is for cooling. The water is circulated to remove waste heat. The objectives in treating cooling water are similar to the objectives in treating boiler feedwater—prevention of scale and corrosion. The main difference between the two applications is in the temperature. Boiler feedwater temperatures range as high as 700 F for the water itself, with even higher temperatures for superheated steam. Cooling water temperatures, however, seldom exceed 200 F and are usually far less.

Several factors must be considered to determine whether cooling water is to be used once and discarded ("once-through" cooling system) or whether it will be used again (recirculating cooling system). These factors are the availability of the water, the temperature, both initially and after being heated, and the cost. In the once-through system, the problems are generally caused by calcium carbonate scale, occasionally iron oxide deposition, and corrosion. Corrosion is usually caused by dissolved oxygen, carbon dioxide, and low pH. Scale formation is affected by temperature, rate of heat transfer, calcium, magnesium, silica, sulfate and alkalinity concentrations, and pH. Usually only calcium and alkalinity concentrations and pH are high enough in a once-through system to warrant consideration.

Scale formation is usually prevented by means of suitable chemicals which increase the solubility of the scale-forming salts and permit oversaturation without precipitation as scale. The chemicals normally used are the phosphates, tannins, starches, lignins, and other similar materials. If this treatment is insufficient, it may be nec-

essary to adjust the pH or alkalinity with acid or recarbonation.

Corrosion is usually caused by dissolved oxygen. The rapidity with which it takes place depends on the concentration of dissolved oxygen, pH value, and the temperatures. Low pH, high temperatures, and high concentrations of dissolved oxygen accelerate corrosion. In a once-through system, it is not usually feasible economically to remove all the oxygen, and the normal procedure is to attempt to provide a thin film of calcium carbonate on the metal to reduce corrosion to a minimum. In addition, inhibitors may be added to the water to reduce corrosion. Complete removal of the oxygen is usually too expensive, but reduction to about 0.2 ppm can be accomplished economically.

If the water supply is meager or expensive, it is necessary to recirculate the cooling water, using it over and over again. The water normally absorbs heat from heat exchangers and then goes to water cooling equipment to be cooled and then back to the heat exchangers to repeat the cycle.

The water may be cooled in several ways. In the open circulating system, cooling towers—mechanical forced draft and natural draft—and spray ponds are used, whereas in the closed system, refrigeration is used. Conditions are aggravated in the open system by the concentration of solids caused by evaporation and windage losses, and by the saturation of the water with oxygen and contamination with industrial gases. To prevent oversaturation of the scale-forming salts, blowdown is used to limit the concentrations to a maximum limit. If it is not economically feasible to control the solids with blowdown, it becomes necessary to resort to cold lime-soda softening or sodium cation exchange or to the use of acid for reduction of alkalinity. Sulfuric acid, which, is usually used for the acid treatment because of its low cost, reacts with the bicarbonates to form the more soluble sulfates and carbon dioxide.

Corrosion is also a greater problem in the open circulating system because of the increased amount of oxygen. The normal treatment is the same as in the once-through cooling system—the use of phosphates, chromates, amines, and other chemical inhibitors. Continued treatment will form a thin protective film on the metal surface which can reduce corrosion as much as 90 to 95 per cent.

Slime and algae, which retard heat transfer, are problems in the open circulating system. Treatments for slime and algae include dosage with chlorine, copper salts, phenolic compounds, and mercury compounds. The cause of the trouble must be identified before a remedy may be prescribed.

Summary

Although the desired end results of treatment for boiler feed and cooling water differ from those desired for municipal waters, the problem is essentially the same and the method of solving it is exactly the same. The type of raw water available must be analyzed to determine its constituents, the end result must be determined, the proper process must be selected, and finally, a rigid control system must be set up and maintained. Again it should be stressed that there is no one cure-all. Every individual station, municipal or industrial, must be examined and analyzed by people who are properly grounded in water treatment.

Experience With Filter Underdrains at Lewiston, Idaho

By Winston H. Berkeley

A paper presented on May 17, 1951, at the Pacific Northwest Section Meeting, Vancouver, B.C., by Winston H. Berkeley, Filter Plant Supt., Water Dept., Lewiston, Idaho.

RECONSTRUCTION of four filter units at the Lewiston plant was recently completed, using porous plates for the support of filter media. Investigation of filter underdrains disclosed several different types of systems which have been in use or are now being used.

Until recently, the most generally accepted method of construction of rapid sand filters involved supporting the sand on approximately 18 in. of graded gravel, the underdrains usually consisting of a system of cast-iron headers and laterals placed in the bottom layers of the gravel. Although this method of filter construction is the most common, it leaves something to be desired—at least, from the operator's viewpoint. The clogging of the underdrains by tuberculation and the displacement of the filtering materials, resulting in the ultimate breakdown of the filter, are two of the most serious drawbacks of this construction method.

In an effort to overcome the defects and instability of gravel-supported filter media with metal underdrains, several types of filter bottoms have been developed—some successful, others undesirable. In some of the first filters built, an attempt was made to hold the filter materials in place by tying down the gravel with brass screens bolted to anchor piers. Several types of strainer systems were later developed and have been used in some eastern plants. Another type of filter underdrain is the "Wheeler" bottom, which is structurally, perhaps, the most complicated. In this type, the concrete filter bottom is built in a series of inverted, truncated pyramids. At the apex of each pyramid is a pipe opening which leads to a collector or header. In the pockets are placed a certain number of concrete or glazed-earthenware spheres of approximately 3-in. diam; then approximately 10 in. of $\frac{3}{4}$- to $\frac{3}{16}$-in. gravel is placed over the spheres.

Two of the more recent developments in filter drains have been "Leopold" bottoms and the abrasive porous plates * shown in Fig. 1. Both of these bottoms do away with all metal piping within the filter. The abrasive plates also completely eliminate the gravel, so that, except for the sand, no loose filter material is required.

"Leopold" filter bottoms consist of a hard, salt-glazed tile. The top side of the tile is perforated with many small holes. A shallow layer of fine gravel is placed over the tile to support the sand and prevent it from passing through the perforations.

Although no evaluation of the faults or virtues of any of these systems is offered, an account of experiences, prob-

* The plates are made of "Aloxite," an abrasive manufactured by Carborundum Co., Niagara Falls, N. Y.

lems, and solutions at Lewiston may be helpful.

Difficulties With Gravel Construction

The author's first experience with filter underdrains occurred many years ago in the small Wenatchee plant, built in 1921. This plant had four filter units of the usual gravel and sand construction. The header was cast iron and the laterals wrought iron with double perforations at 6-in. intervals. A 1½-ft layer of gravel supported 30 in. of sand. This small plant had a rated capacity of 2.5 mgd, and, in the summer, it was necessary to operate it at a 3.5-mgd rate. The filter materials became badly displaced, and the filters had to be rebuilt in 1925. Since 1927 this plant has been used only during the summer months. It is not at all likely that the summer overload contributed to the derangement of filter material. The probable cause of the filter derangement will be discussed briefly later.

The second Wenatchee plant was built during 1926–27. It has four filters and a rated capacity of 4 mgd. The filters were built to the same specifications as the first group, except that brass eyelets were used in the perforations. The filters were rebuilt in 1934, or approximately eight years after original construction. The sand and gravel had become so badly displaced that they would no longer wash properly, and much trouble was experienced from entry of filter sand into the clear well. The sand caused trouble in gate valves and other equipment in the plant.

Fig. 1. Abrasive Plates
Details of the plates as they were being laid are shown.

The gravel sizes and depths and the lateral perforations in these eight filters conformed to the prevailing specifications. The displacement of the filter materials cannot be blamed for an improper wash rate. The wash rate was determined and thoroughly checked when the plants were completed. Pieces of pipe were placed in the hydraulic cylinders of the wash water valves so that they could be opened only to a certain point. Filter washing

was always done carefully. If the human element was involved in the breakdown of these filters, it was so only to the extent which must be expected in the operation of any equipment and not to the point of negligence.

The Lewiston filter plant was built in 1924. Rated capacity is 6 mgd. There are four filter units, each of which is approximately 24 ft square. On the floor of each filter unit were placed two cast-iron headers, rectangular in cross section, from which 2-in. cast-iron laterals branched out on 6-in. centers. Each lateral had two rows of $\frac{3}{8}$-in. holes on 6-in. centers. To provide wash on top of the headers there were two rows of strainers. The gravel varied in size from 3-in. rock on the bottom to $\frac{3}{16}$-in. on the top and was 18 in. deep, supporting 30 in. of sand. The sand has an effective size of 0.35 to 0.45 mm and a uniformity coefficient of 1.4. The filters have been reconstructed twice since the plant was placed in operation in 1924. In 1934 everything was removed from the filters. The underdrains were cleaned and painted, and all sand and gravel was carefully regraded. The heavy rock was painstakingly placed around the headers and laterals by hand. The maximum rock size was increased from 3 to 5 in. at that time.

In the Lewiston plant, the disarrangement of filter materials, which seems to be characteristic of this type of construction, was further aggravated by corrosion and tuberculation in the cast-iron laterals. The tuberculation had practically closed some of them and had badly obstructed others. In some laterals, the perforations were blocked by these corrosion products and, in others, the holes were enlarged. The end result was that, by the time reconstruction of the last two filters was started, it was nearly impossible to wash them at all.

Displacement of the gravel and sand in the above type of filter takes place even when the piping and underdrains are in good condition, as they were in the Wenatchee plants. The explanation seems to be that, when the filter is in operation, the sand is not evenly compacted. Some sections accumulate more floc than others. When the wash water is applied and upward pressure exerted, the weaker places give way first, and the wash water rushes horizontally to these points through the voids in the coarse gravel. The finer gravel is easily carried along and piles up in those areas, so that a pattern soon develops, and the condition grows progressively worse.

Other Experiences

Corrosion in the laterals was accelerated by the use of Clearwater River water which is very soft and is saturated with oxygen. To inhibit corrosion, the pH of the settled water is corrected before filtration. Also the laterals were painted with a protective compound when installed and again when the filters were last rebuilt.

When it first became evident that the filters would again have to be reconstructed, it was decided to investigate all types of filter underdrains to see if a more modern, stable type of construction could be used in rebuilding the filters. After consideration of the different types and methods now in use, it was decided to investigate the use of porous abrasive plates to determine their efficiency in other installations. One reason for selecting the plates was that they appeared to be less difficult and less expensive to adapt to the old filter construction.

Many very encouraging letters were received. The most distant city from

which information was received was Nykoping, Sweden, where there was an iron- and manganese-removal plant in which abrasive plates had been in service for ten years at the time of the report. This installation was also interesting because the plates were laid with asphalt rather than mortar joints. It was reported that they had given complete satisfaction, and, although the exact method used in installing them was difficult to understand, the operators were very happy over the successful results.

The city reporting the largest installation of porous plates was Austin, Tex., which has a lime-softening plant that does not use recarbonation but lets the filters act as stabilizers. This practice causes encrustation and build-up of the sand and lime deposits in the underdrain system. The sand and plates are cleaned periodically with muriatic acid. This practice might be termed putting porous plates to the acid test. At the date of the report, this method seemed to be operating satisfactorily.

A number of other reports were received including one from the Cornell University plant. Fortified by the knowledge gained in this investigation, the Lewiston department decided to proceed with installation of the abrasive type filter bottom.

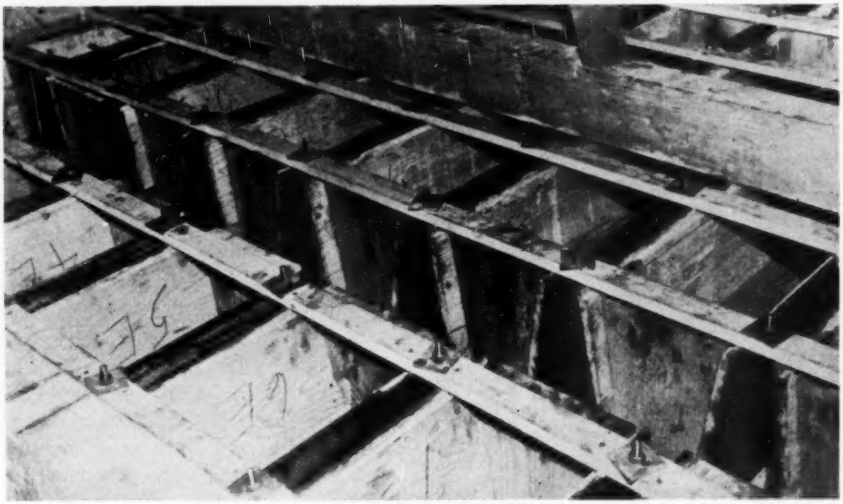

Fig. 2. Pier Forms

Details of the pier forms can be seen. The templates are shown with the special bolts in place. Shown also is one of the five cross channels to equalize the flow of wash water.

Preparation for Installation

In preparation for rebuilding the old filters, the sand was removed and screened. The gravel was taken out and discarded. The laterals and headers were removed, and the filter box was cleaned and dried. The rectangular headers had been grouted into the floor of the filter, and it was found simplest to break them up and remove them in pieces. The tees in the center of the headers were left to act as baffles for

the wash water. These tees are approximately 2 ft long and the same shape above the floor as is the header.

When sand removal was started, it was found that, in places, the gravel came within 8 in. of the top of the sand. The contour of the gravel resembled a relief map of some of the Idaho mountains. It is rather surprising that some of these filters did not break down completely, as the filter materials were so badly disordered.

Plate Supports

After decision to use the abrasive plates in the rebuilding of the filters had been made, it was decided to support them by means of concrete ridges, or piers, on two parallel edges, and tie them down with special bolts and washers * as shown in Fig. 2. The piers were made 2 in. wide at the top, 6 in. at the bottom, and were placed on 1-ft centers. They are lightly reinforced and are 14 in. high, which, with the plates, gives an overall height of $15\frac{1}{4}$ in. The gravel depth was 18 in., thus lowering the sand surface $2\frac{3}{4}$ in.

The floor of the filters was scarified where the piers were to rest. Holes were drilled on the center lines, and short pieces of reinforcing steel to serve as anchor rods were set in the holes with lead. Five 10-in. cross channels are provided for the distribution and equalization of the wash water to the channels between the piers.

In building the forms for the piers, an order was placed with the local sash and door factory to cut wedges of pine to exact dimensions. The form lumber was nailed to these wedges, providing form sections approximately 11 ft long which were very easily handled. These sections were placed side by side on the filter floor. They were spaced and tied together by the templates for the special bolts, which were located on exactly 1-ft centers. The forms were well greased before being placed. The concrete was poured between them, and, when it set sufficiently, the forms were removed and used in the next filter.

The abrasive plates were laid by the assistant plant superintendent and the author using a special cement mortar made with fine plaster sand.* The edges of the plates were buttered with mortar and shoved together (Fig. 3). The utmost care was necessary in spacing, as there is only $\frac{1}{4}$-in. space between plates. The dimensions of the plates are $11\frac{7}{8} \times 11\frac{7}{8} \times 1\frac{1}{4}$ in. Rubber hammers were ideal for placing the plates.

Expansion space is provided between the plates and the walls of the filter. A supporting 2-in. wide ledge was built of reinforced concrete to the same height as the piers, completely around the filter walls. The space on top of this ledge between the edges of the plates and the filter walls was filled with a compound that was to act as an expansion joint.†

The special cement mortar was used because it contains no calcium or magnesium but is composed of aluminum oxide and cannot be leached out or weakened by a lime-hungry water. The filter sand and plates can be cleaned with acid without injury to the mortar. This cleaning will probably never be done in Lewiston, but it is being done in Austin.

As the plates were laid, the bolts and washers were placed, and the nuts were screwed down a little more than

* The bolts and washers were made of "Everdur," a product of American Brass Co., Waterbury, Conn.

* "Lumnite," a product of Reardon Co., 2204 N. Second St., St. Louis, Mo., was used.

† "G-K compound," a product of Atlas Mineral Products Co., Mertztown, Pa., was used.

finger tight. Enough mortar is used in laying the plates to compensate for any slight unevenness of the tops of the piers and to provide perfect bearing when the mortar has set and the bolts are tightened with a wrench. The abrasive plates are brittle but will bear a surprising load when properly supported. They are designed to carry monument makers use a small air-driven chisel for such work, a plate which was broken in shipment was taken to the local monument works manager, who, after experimenting briefly, found that it could be cut easily. He undertook to do the work, and a considerable number of plates were cut without loss or breakage.

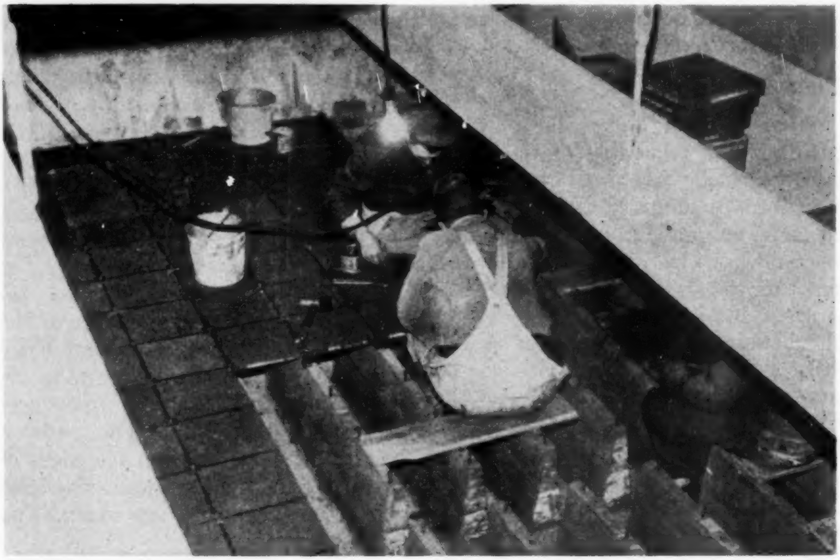

Fig. 3. Laying of Porous Plates With Cement Mortar
Rubber hammers were used to tap the plates into position, thus avoiding breakage.

800 lb on a $\frac{1}{2}$-in. strip in the center if supported on two parallel edges.

In measuring the filter box to locate the ridges or piers, it was found that the walls were not all in perfect alignment and some of the dimensions varied quite a bit from the blueprint. It was apparent that a number of the filter plates would have to be cut to make them conform to the filter-box measurements. This problem gave the operators some concern, because corundum is both exceedingly hard and brittle. When it was recalled that

Other Plate Support Methods

The new addition to the Wenatchee filtration plant has four filters with abrasive-plate construction. The plates in these filters have a different type of support from that used in the Lewiston plant. No concrete ridges are used, but the plates are supported by means of bolts which are set in the filter floor. These bolts are fitted with double nuts and washers. The bolts come at the points where the corners of four plates come together. Each plate is thus supported on four corners.

The Washington Water Power Co. in Clarkston, Wash., is building a filter plant in which abrasive plates mounted on concrete ridges are being used. This installation is unusual in that the piers are 30 in. high. Presumably, the designer has used this method of securing wash-water distribution rather than providing wash-water channels dropped below the level of the filter box floor. The filter plant on McNeil Island, Wash., is also equipped with these plates.

Head Loss Through Plates

The loss of head built into the plates is approximately 0.7 ft at the normal wash rate. At a wash rate of 15 gpm per sq ft, the head loss through the plates and sand is estimated to be approximately 1.0–1.5 ft. The possibility of clogging of the plates, with the attendant increase in loss of head, was carefully considered. This condition has not occurred where the plates are now in use, except in one installation in which raw water is used for backwashing. The Wenatchee and Lewiston operations are carefully controlled. The pH and alkalinity of the settled water are regulated and kept below the incrustation point. Pretreatment with chlorine-ammonia is used with a dosage of 1 ppm or more, precluding the possibility of slime formation or bacterial growth.

Cost of Installation

All of the work of remodeling these filters and the installation of the plates was done by unskilled labor under the supervision of plant personnel. Two of the filters were completed in the middle of 1950 and the other two at the end of that year. The total cost of each pair was almost identical. Labor was more expensive for the latter pair, but other savings just about compensated for it. The cost of the plates delivered in Lewiston was approximately $1,500 per filter, and the total cost of the completed job was approximately $3,400 for each unit. The cost to rebuild the installations with the old materials was not estimated, but, with the laterals in such poor condition and the amount of labor involved, it would not have been much cheaper, and the old trouble would necessarily have been retained. The price quoted for the "Leopold" bottoms was nearly twice that for the plates.

Summary

In all four of Lewiston's filter units, iron piping has been entirely eliminated. The problem of deterioration of the underdrain system is fully solved. The gravel is out and can no longer constitute a source of trouble. Nothing is loose in the filter but the sand and that rests on a strong, rigid supporting structure, composed of plates of crystalline alumina, or corundum—one of the hardest, most durable substances made by man. The plates, in turn, rest on reinforced concrete and are held in place by bolts made of a practically indestructible alloy.

By these improvements a permanent filter structure has been built which is fully capable of withstanding the physical strains of the service to which it is put. Neither the corrosiveness of the water nor its solvent action will have any effect on this equipment. The filters should last as long as the building which houses them. The manner in which they wash is certainly a thrill for any operator, and it would be very difficult to find anything about the system to criticize. The filters have withstood all tests so far, even sudden subjection to the full force of the wash water by opening the valve wide while the sand is at rest.

Minimizing Hazards in Water Works Industry

By Jerome Powers

A paper presented on Feb. 14, 1952, at the Indiana Section Meeting, Indianapolis, by Jerome Powers, Div. Mgr., American Water Works Service Co., Richmond, Ind.

IT is difficult to outline the safety problems of the water works industry because of the varied types of equipment and installations. The safety department of the author's company has made various analyses of accident records covering the 5-yr period 1946–50. Some of these statistics will be condensed into statements of condition which have proved valid.

Accident Statistics

The accident frequency rates for utilities managed by the American Water Works Co. for the 1946–50 period have been slightly above the national average for public utilities of all types, whereas the severity rates have been slightly under the national average. This means that a larger number of the less serious types of accidents have occurred, probably because of the wide diversity of work activities, the large number and variety of hand tools used, the unaccustomed and unusual working areas often encountered, and the infrequent use of large and dangerous equipment.

The statistics show that bruises rank highest among injuries sustained by the company's employees. Following bruises, in order, are lacerations, strains, eye irritations, sprains, burns, dog bites, fractures, punctures, abrasions, weed poisonings, and crushes. Less frequent injuries include hernia, infection, heat exhaustion, insect bites, dermatitis, dislocations, and electric shock. Of the total of 2,071 employee accidents which occurred during this 5-yr period, 1,469 of them, or 70 per cent, resulted in bruises, lacerations, strains, eye irritations, and sprains.

As lost time constitutes a large part of the cost of accidents, the 1950 statistics showing which injuries resulted in the most lost time are of interest. Fractures resulted in the greatest loss of time. Strains and sprains, considered as one type, accounted for 31.5 per cent, and bruises accounted for 13.8 per cent of all lost time. As a group, fractures, strains and sprains, and bruises resulted in approximately 80 per cent of all the lost time in 1950. With the exception of lacerations and burns, the lost time percentages concur with the frequency percentages.

This information can be of value in eliminating hazards if the types of accidents which cause fractures, strains and sprains, and bruises can be determined. The determination of cause, however, is one of the most difficult problems encountered in accident prevention. The result of an accident is usually the major concern, and frequently much time elapses before the

cause of the accident is investigated. Recognizing the cause, or hazard, however, is the answer to the accident elimination problem.

Fractures are frequently caused by falls; thus, anything that will reduce the frequency of falls will reduce fractures. Falls are frequently caused by failure of supports which hold workers, objects which cause tripping, slippery walking areas, and the carrying of objects which are too heavy. These same hazards will also account for bruises and for strains and sprains.

Specific hazards can be removed, but usually as fast as visible hazards are removed, new and sometimes invisible hazards develop. The greatest of all hazards is the one that cannot be seen or isolated—the hazard within the mind of the worker.

The Safety Committee

The foremost approach to accident elimination is an organizational device —a safety committee for each separate plant under the general supervision of the company manager. In order to secure uniformity, the author's company has a safety director who coordinates all safety activities through the various division managers.

Safety activities at the plant level have consisted of safety meetings, plant inspections, and action on specific recommendations. In some plants both the safety committee and its chairman are appointed by the manager, whereas in other plants the manager appoints the committee but the committee selects its own chairman. Sometimes the committee serves indefinitely but short periods of two, four, or six months offer the advantage of giving a larger number of workers an opportunity to work actively with safety methods, and the committee does not grow "stale."

The safety meeting is usually held on company time and lasts from 30 min to 1 hr. The minutes of the previous meeting are read and discussed, details of recent accidents are outlined, and efforts are made to determine the cause. Copies of safety publications, recent safety posters, and articles on specific safety problems distributed by the safety director are read and discussed. Whenever possible, capable speakers, such as Red Cross representatives, nurses, doctors, police or fire officials, or other persons engaged in the general field of safety, are secured for short addresses.

A safety inspection is made by one or more members of the safety committee once a month. Insurance representatives are frequently invited to join the trip over the physical plant. Usually one member is placed in charge of first aid kits and bulletin boards; on this trip he refills needed items in safety kits and replaces posters and notices. All items which, in the opinion of the committee, need correction are noted and included among the recommendations. The trip is reported on a safety inspection report form which is sent to the safety director. Recommendations and progress on recommendations are recorded in a special notebook. The recommendations may cover any phase of plant activity or equipment and represent the basic source of improvement in plant activities and facilities.

Thus, the problem of eliminating hazards has been approached in several ways. The practical approach—applying guards, handrails, warning signs, and similar physical appliances that are easily seen and recognized as protection against hazards—has been utilized. In addition, the educational approach

—teaching safety through reading material, motion picture films, eye-catching posters, and short talks—has been tried. Worker interest has been sought through participation in all of the various aspects of the safety program.

The Hidden Hazard

The evidence seems to point toward the hidden hazard in the mind of the worker as the most fertile field for cultivating the thoughtful type of work activity which will practically prohibit the recurrence of accidents. H. W. Heinrich of the Travelers Insurance Co. has said that 2 per cent of all accidents cannot be prevented. Therefore, 98 per cent are preventable. In addition, Heinrich's studies indicate that of these 98 per cent, 10 per cent are due to unsafe mechanical or physical conditions and 88 per cent are due to unsafe acts of persons. These findings point directly to the hidden hazard.

In order to attack the hazard of the unsafe act, the motivation for which lies in the worker's mind, ways and means of creating and maintaining an interest in safety must be considered. This aspect of the safety program can be handled mainly by the plant managers and foremen. Facts should be gathered and procedures set up for analyzing them. Remedies should be selected and corrective action applied. Physical safeguards should be used wherever feasible, and new and better tools, machinery, and processes which have incorporated in their make-up a provision for safety should be sought. Every reasonable pressure to see that safety measures and guards are used wherever and whenever provided should be exerted. But, through the foremen, the hidden hazard in the minds of the workers can be reduced even further by means of newer techniques.

Safety Motivation

On the assumption that the foremen and the workers are people, and that as people they are alike, and at the same time, as individuals, they are different, the following characteristics can be utilized:

1. Self-preservation. All normal persons have a fear of personal injury and for this reason alone, will aid in accident prevention, if the proper appeal is made.

2. Personal and material gain. Most people have a desire to add to their possessions. This desire can be enlisted to promote safety by means of group or individual awards, such as paid vacations, salary increases, and bonuses.

3. Loyalty. Most people can be induced to cooperate and be loyal. Loyalty is nourished by friendliness and interest on the part of superiors.

4. Responsibility. A great many workers will, on the basis of personal responsibility, improve their work and safety record if gradually given, with friendliness and consideration, additional duties.

5. Pride. Almost all good workers take pride in their work and seek praise. Praise can be given when merited without loss to the company and with much possible gain.

6. Conformity. People in general like to conform to the group in which they find themselves. Thus, as a work group becomes more interested in safety, individual members have a tendency to seek safety in order to be more like the others.

7. Rivalry. Just as the desire to compete and excel is used to expand production, it can be used in seeking better and better safety records.

8. Leadership. The desire to lead is general and can be utilized to promote safety as well as quality and quantity of production.

9. Logic. Many people can be reached with success on the basis of common sense or reason, using, perhaps, one or more of the other desires.

10. Humanity. The desire to help others can be channeled toward safety for others—in fact, the history of safety engineering has been motivated in large part by humane considerations.

Foremen should become aware of these common characteristics or desires and use them in their daily contacts with the workers. A little effort on the part of a foreman to use one or more of these desires in his handling of a worker will probably result in a mutual growth of friendship and fellowship. If a foreman will try to help (humanity) a worker do a job in the accepted manner (conformity), he will discover that he is also appealing to the worker's pride, loyalty, logic, or sense of responsibility, and by this demonstration of friendliness he may learn many things about the worker that will help him make the worker a better man, and therefore, a better worker. To the worker, the foreman is the company. What he thinks about the foreman is quite often what he thinks about the company, and what he will do for the foreman is quite likely what he will do for the company. Thus, the foreman is in a position of prime importance in reducing accidents just as he is in controlling quality, cost, and quantity of production. Efforts with the foremen must be increasingly effective. It should be remembered that the foremen are also people and are affected by the same desires as the workers.

Human Understanding

An individual may be greatly affected by an appeal to his desire for self-preservation and give a negative response to an appeal based on pride, or he may require appeals based on two or more desires in combination. It is not likely that any foreman will find any two of his workers reacting in the same manner to his technique in appealing to their basic desires. There are many supplementary and minor desires which the alert foreman will detect in employees under his supervision.

It is necessary to understand human desires because they affect human behavior either beneficially or detrimentally, even if they are totally ignored. Some individuals are endowed with an overabundance of some of these desires, and, in pursuit of them, ignore completely their fellow workers. A show-off or daredevil will endanger himself and others in order to satisfy his strong desire for attention. An understanding foreman can frequently channel these desires constructively by showing the individual that accepted behavior patterns elicit more approval than unaccepted patterns.

Repetition

Repetition can also be utilized in minimizing hazards. Its use has been fundamental and successful in the advertising business. A slogan can be presented so frequently that the reaction to it becomes almost automatic.

An interesting and continuing flow of facts on safety matters should be directed to the foremen and workers. Each time the consciousness of an employee is assailed by an idea on safety, he will grow a little more safety-minded. Even a minor act, such as

reading the word safety on a card or in a letter will have a cumulative effect on a worker's awareness of safety. The author's company reaches the workers' attention by direct reading material through a bimonthly publication, "Safety News," as well as through general bulletins on particularly needed safety subjects.

Conclusion

The accident records and statistics of a multiplant water works business have been examined. Certain types of accidents have occurred more frequently than others and have resulted in lost time. All, or even a majority of accidents, cannot be prevented by physical guards or precautions. The most effective approach to hazard removal has been through the foreman or supervisor to the individual worker. The workers have been asked to consider safety as a right, privilege, and duty just as voting is. The author feels these methods will show results, not in a week, month, or year, but after several years of continued and sustained effort. Steps which will result in company benefits, including reduced frequency and severity rates, are:

1. Prepare, adjust, adapt, and use physical guards wherever practicable, paying close attention to those hazards in which the physical guards were not a part of the original equipment but were added later. Keep abreast of newly invented safety appliances.

2. Concentrate efforts on the foreman. He more than any other person can recognize and scrutinize those hazards with which his men come in contact. His relationships with his men, if he is a good foreman, will give him an "in" with his workers that no one else can secure, and through him the workers can be hit and hit again with repeated facts on safe work practices.

3. Don't forget the worker, the man of whom it can be truly said, "he makes or breaks the firm." Attention to the worker plus the foreman's intimate knowledge of his men will result in a water works plant with fewer and fewer hazards as the years go by.

NPA Reclassification of Water Systems

Effective July 1, 1952, water and sewage systems are reclassified by the National Production Authority from the commercial to the industrial category of construction, thus providing a substantial increase in the amounts of controlled materials for which purchase orders may be self-authorized per quarter per project:

	New Amount	Old Amount
Carbon steel—tons	25 *	5 †
Copper—lb	2,000	200 ‡
Aluminum—lb	1,000	100 ‡

* 25 tons of carbon and alloy steel, including all structural shapes but not more than 2½ tons of alloy steel and no stainless steel.

† 5 tons of carbon steel, including no more than 2 tons of structural shapes and no wide flange beam sections.

‡ 200 lb of copper and copper-base alloys, or 100 lb of aluminum.

The dollar value of other than controlled materials (including B products) available under the industrial classification is also much greater than for the commercial classification. Under the industrial classification water and sewage systems are authorized to use a DO rating to secure other than controlled materials (including B products) for any entire single construction project with a dollar value not in excess of $100,000 for building materials and equipment and not in excess of $200,000 for production equipment and machinery. Under the commercial (old) classification the comparable figures are $15,000 and $5,000.

This revised regulation may be used to order materials that will not be delivered prior to July 1.

Economic and Technical Status of Water Reclamation From Sewage and Industrial Wastes

By Raymond V. Stone Jr., Harold B. Gotaas, and Vinton W. Bacon

A paper presented on Oct. 26, 1951, at the California Section Meeting, San Francisco, by Raymond V. Stone Jr., San. Engr., and Harold B. Gotaas, Director, both of Sanitary Eng. Research Project, University of California, Richmond, Calif., and Vinton W. Bacon, Exec. Officer, State Water Pollution Control Board, Sacramento, Calif.

In certain California regions, the demand for water nearly equals or exceeds the readily available fresh water supply. Because of the inadequacy of the supply, these regions have been termed "water-shortage" areas. Even with critical water shortages, however, many of these areas continue to grow in population. To alleviate the shortages—both present and future—extensive engineering studies to determine new water sources are now being conducted.

A plausible method of *augmenting* a water supply, which heretofore has not received adequate consideration, is the reuse or reclamation of water now wasted—in domestic and industrial sewage. In the past, researchers and engineers (1–3) have demonstrated that water usable for practically any desired purpose can be reclaimed from sewages by employing modern technological methods. General interest in these methods has not been great because the water needs could be met satisfactorily with other readily available fresh water supplies. Today there is greater public interest in reclamation of waters now wasted to the ocean as sewage effluents. Sewage, the raw material for reclaimed water, exists in many local "water-shortage" areas and can be utilized within these areas.

Types of Reclamation

The treatment processes necessary for water reclamation are those employed in present-day sewage disposal and water purification practice. The intended use and financing of the works are the differentiating factors between sewage disposal and water reclamation—that is, who is paying for the treatment, and are the works intended for reclamation or disposal?

There are two types of reclamation: incidental reclamation (Fig. 1) is the use of effluents from sewage treatment plants, planned and financed for sewage disposal; planned reclamation (Fig. 2 and 3) is the production of usable water from liquid wastes.

The wide practice of incidental reclamation throughout the world demonstrates that a usable water, meeting

set requirements, can be produced from most sewages. There are few planned reclamation projects in this country. Legislation and procedures for the organization and financing of sewage reclamation projects are not well developed. Difficulties may arise for planned reclamation projects because of the lack of precedents establishing the obligations and authority of the reclamation and disposal interests. Needless to say, the integration of the reclamation and disposal activities to make maximum use of all facilities, without detracting from the responsibilities of either agency, is necessary for successful operation.

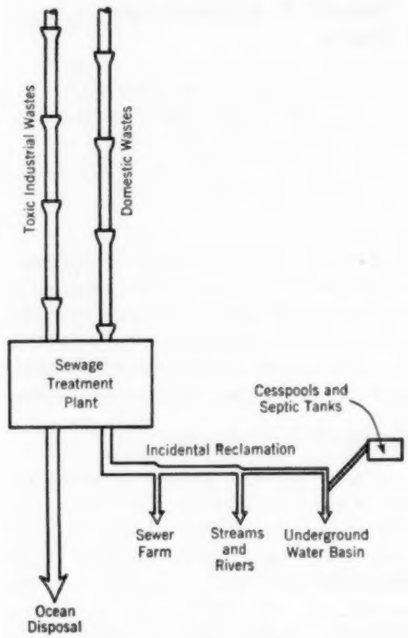

Fig. 1. Incidental Reclamation

The use of effluents from sewage treatment plants planned and financed for sewage disposal.

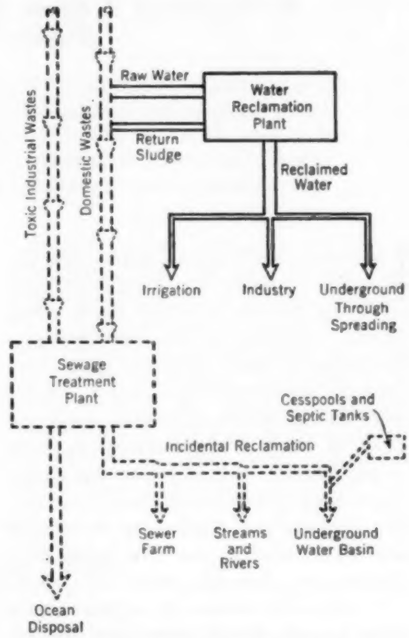

Fig. 2. Planned Reclamation

The water reclamation plant is a planned enterprise separated from sewage disposal.

The cost of the planned reclamation projects will be the cost of the "extra" treatment and processing required beyond that necessary for sewage disposal.

Direct use of effluents from water reclamation projects can be employed by a variety of agricultural, industrial, and recreational consumers. Indirect use of reclaimed water can be accomplished by returning the water to natural shortage where it can be drawn upon for general use.

Agricultural Uses

The principle utilization of reclaimed water has been for irrigation. European countries, particularly Ger-

many, have made considerable use of such water. In 1939 the sewage from one-fourth of the sewered population of Germany, including Berlin, Leipzig, and 67 other German cities was employed for irrigation (4). The Germans have developed new irrigation

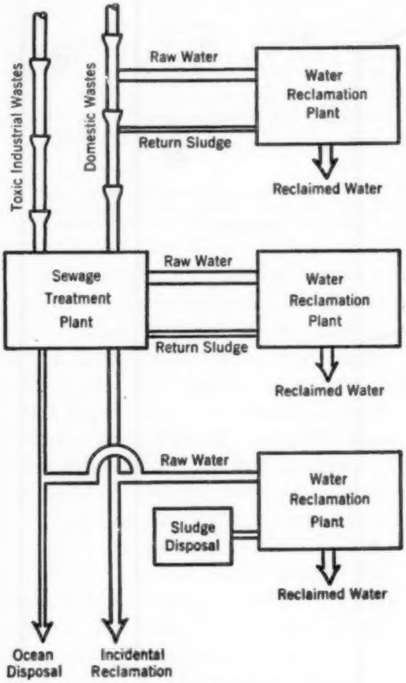

Fig. 3. Planned Reclamation

The water reclamation plant location is determined by economics and water use. It can be located above, adjacent to, or below the sewage treatment plant.

techniques which include artificial rain and frequent application of small quantities of water rather than heavy flooding. Because of the emphasis placed on conservation, the development of modern sewage treatment works in that country has been modified to insure the fullest agricultural utilization. In general, German techniques have been successful, except with respect to the public health. Imhoff (2) reports that certain areas were infested with round worm because of raw sewage irrigation during World War II.

Instead of modifying treatment works to meet the needs of agriculture, France unsuccessfully practices sewage irrigation as a means of sewage disposal. During the rainy season the effluents cannot be adequately handled, and during the dry season the supply is inadequate. Many of the sewage farms have caused such odor nuisances that extensive buffer strips are necessary.

Among other countries using sewage for irrigation are Spain and Italy. In Milan slope irrigation is successfully employed for grasslands, and subsurface irrigation for truck crops. Hygienic and public health objections to these practices have disappeared as a result of observation and use over a long period.

In addition to sewage farming, other reclamation methods have been employed in Europe. One unique method is the use of fish ponds at Munich. This method is limited to regions with large areas for ponding and sufficient fresh water with which to dilute the sewage.

In this country, sewage farming has been used mostly in the arid and semi-arid regions of the southwestern states. In a 1948 census, 124 places using this method were listed by Veatch (5). In 1950 the records of the Bureau of Sanitary Engineering of California's State Dept. of Public Health showed that, not counting places employing broad irrigation without cropping, 69 communities in that state used sewage for irrigation.

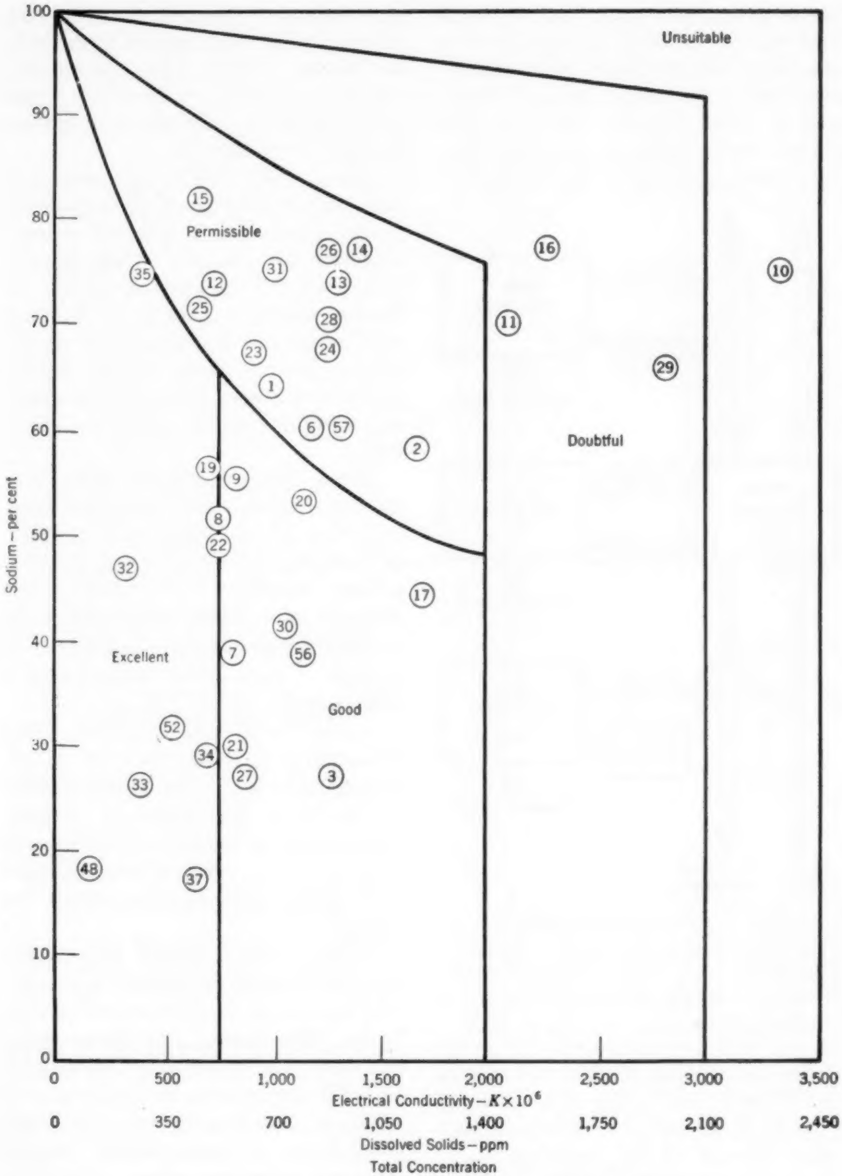

Fig. 4. Sodium and Dissolved Solids in Irrigation Waters

The limits of sodium and dissolved solids concentration for several classes of irrigation waters are shown. The numbers refer to actual fresh or reclaimed waters listed in Table 2.

TABLE 1 *

Permissible Limits for Total Concentration of Sodium, Boron, Chlorides, and Sulfates

Irrigation Water Class	Total Concentration as		Proportion Sodium‡ *per cent*	Boron (for Crops) *ppm*			Concentration§	
	Conductance $K \times 10^{6}$†	Dissolved Solids *ppm*		Sensitive (Fruit Trees)	Semi-Tolerant (Vines and Cereals)	Tolerant (Vegetables)	Chlorides (Cl^-)	Sulfates ($SO_4^=$)
1. Excellent	<250	<175	<20	<0.33	<0.67	<1.0	< 4	< 4
2. Good	250– 750	175– 525	20–40	0.33–0.67	0.67–1.33	1.0–2.0	4– 7	4– 7
3. Permissible‖	750–2,000	525–1,400	40–60	0.67–1.00	1.33–2.00	2.0–3.0	7–12	7–12
4. Doubtful#	2,000–3,000	1,400–2,100	60–80	1.00–1.25	2.00–2.50	3.0–3.75	12–20	12–20
5. Unsuitable	>3,000	>2,100	>80	>1.25	>2.50	>3.75	>20	>20

* Data from this table are reproduced in graphical form in Fig. 4 and 5.
† Measured in mhos per cm at 25 C.
‡ Ratio of sodium to the total cations expressed in equivalent weights. Calculated from the formula $\frac{Na \times 100}{Na + K + Ca + Mg}$.
§ Measured in milliequivalents per liter.
‖ When three or more concentrations are Class 3 or higher, the water is unsuitable.
\# When two or more concentrations are Class 4 or higher, the water is unsuitable.

Sewage irrigation projects have experienced notable successes and failures. Although some of the failures may be attributed to poor and inadequate design, the quality of operation is most important. As a result of these successes and failures, valuable data have been obtained for the design and operation of sewage irrigation projects. Regulation of sewage irrigation, to protect the public health, has been adopted by health authorities. Because of health hazards resulting from projects that failed, existing health regulations are necessarily severe, and will continue to be severe until the validity of lower standards has been demonstrated through research and experience.

Industrial Uses

Industry, like agriculture, has practiced water reclamation for many years. Reclaimed waters have been particularly suited for cooling, for which large quantity rather than high quality is the prerequisite. Powell (6) states that industry can profitably employ reclaimed waters for plant processing, boiler feed, sanitary uses, fire protection, air conditioning, plant cleanup, and lawn sprinkling. He does not advocate that reclaimed waters be used in processing products for human consumption, as the treatment and sanitary complications would be impractical and costly.

Veatch (5) lists three conditions necessary for industrial use of reclaimed water: [1] A local industry needing water, [2] a local sewerage system with an adeqate sewage supply, and [3] and additional cost of processing and delivery less than the cost of other water supplies.

Wolman (7, 8) describes the industrial use of reclaimed water by a steel mill in Baltimore and Veatch (5) lists ten other places where industry is using, or is planning to use, sizeable amounts of reclaimed water. In addition to these, the Kaiser steel mill in Fontana, Calif., reclaims and reuses nearly all of its industrial and domestic sewage. Industry in water-shortage areas will undoubtedly make increasingly greater use of reclaimed water.

In addition to industrial and agricultural applications, reclaimed water has been used for irrigating parks,

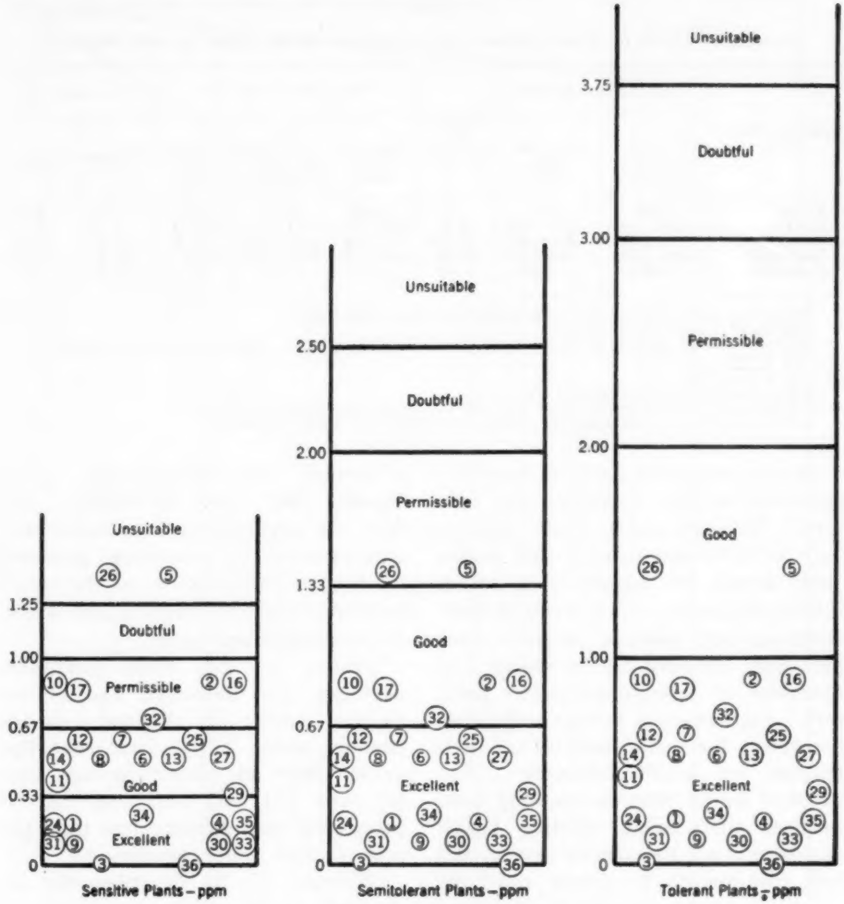

Fig. 5. Boron in Irrigation Waters

The limits of boron concentration for several classes of irrigation waters for plants of varying sensitivity are shown. The numbers refer to actual fresh or reclaimed waters listed in Table 2.

lawns, and golf courses, maintaining water levels in artificial lakes and ponds, and furnishing water to operate sanitary systems. Two noteworthy projects are those at the Golden Gate Park, San Francisco (3, 9), and at the Grand Canyon in Arizona (10). For twenty years, the Golden Gate activated sludge plant has produced an effluent suitable for park irrigation and has maintained water levels in the Chain-o-Lakes at a cost less than that of the municipal water supply. These two projects, plus those at Herington, Kan., which produces boiler water for a railroad, and at Fontana, Calif., are

the only projects thus far built and operated in this country which can be classified as planned projects having the specific purpose of producing a usable water.

Indirect Uses

In addition to direct uses, there are indirect uses which usually are incidental to sewage treatment. Sewage effluents may be discharged into a water course that subsequently serves as a water supply, or into percolation ponds and underground water strata. Azusa, Hollister, and other California cities make use of percolation ponds for the final disposal of their sewage effluents.

Percolation and agricultural use of reclaimed water can be combined through overirrigation of crops and orchards. The dual utilization of water thus provided is doubly beneficial. The agricultural demand for water is satisfied without pumpage from the ground water basin, while at the same time the ground water basin is recharged with water spread in excess of the agricultural needs.

Recently, interest in planning reclamation through spreading has been shown in Los Angeles County (11) and in Ventura County (12). Both counties are experiencing overdrafts from their ground water basins and are seeking means of alleviating the water shortages. The use of percolation beds for reclaiming water has advantages over other methods. Minimal artificial treatment is required, as the percolate, in passing through porous media, undergoes further treatment and oxidation which safeguards the ground water against contamination; and natural water storage basins are utilized, thus eliminating expensive artificial storage. There are several limitations to this type of operation: porous spreading areas must be reasonably close to the reclamation plant, and deleterious wastes must be segregated before spreading as all sewages are not suited chemically or otherwise for reclamation.

Sewage Spreading Studies

Los Angeles County recently conducted sewage spreading tests at Whittier (11) and Azusa (13). These tests indicated that oxidized effluents could be percolated at a rate of ½ acre-ft per acre per day at Whittier, and 2 acre-ft per acre per day in Azusa, including time for the ponds to dry. The findings for these particular soils and sewages were based on equal spreading and resting cycles.

During the past year, the University of California, in cooperation with the State Health Dept. and the State Water Pollution Control Board, has investigated sewage spreading as a means of water reclamation. This study has been conducted under field conditions at Lodi, Calif. The resulting data indicate that, for the conditions encountered, oxidized effluents percolate at rates varying from 0.10 to 0.60 acre-ft per acre per day. These rates are comparable with those recorded at Whittier. No attempt has been made to duplicate the Azusa studies at Lodi because of the great difference in the soils—Hanford fine sandy loam at Lodi and large river gravel at Azusa. In an attempt to increase the percolation rates, some of the Lodi plots were spaded at regular intervals. Spading approximately doubled the percolation rate.

In Kern County, Calif., the U.S. Dept. of Agriculture (14) has been studying methods to improve the percolation rates of irrigation water in the

TABLE 2

Probable Mineral Content of Reclaimed Waters Compared With Other Water Supplies

Index No.*	Source	pH	Alkalinity $CaCO_3$ *ppm*	Total Hardness $CaCO_3$ *ppm*	Cations: Sodium Na^+ *ppm*	Cations: Potassium K^+ *ppm*	Cations: Calcium Ca^{++} *ppm*	Cations: Magnesium Mg^{++} *ppm*	Anions: Chloride Cl^- *ppm*	Anions: Nitrate NO_3^- *ppm*	Anions: Bicarbonate HCO_3^- *ppm*	Anions: Sulfate $SO_4^{=}$ *ppm*	Dissolved Solids: *ppm*	Dissolved Solids: $K \times 10^6$†	Proportion Sodium‡ *per cent*	Boron *ppm*
	Los Angeles County San. Dist. Trunk Sewers§															
1	San Gabriel Valley Outfall at Whittier Narrows	7.4	—	184	175	20	47	16	131	—	300	176	710		64	0.2
2	Joint Outfall near Joint Disposal Plant	7.1	—	350	Na+K 220	See Na	104	22	170	—	350	310	1,180		58	0.9
3	Dist. No. 1 Main Trunk Sewer, Artesia Street	—	—	460	Na+K 77	See Na	115	41	77	—	362	220	900		27	0.0
4	Dist. No. 2 Main Trunk East'n. Ave. N. of Garfield	—	—	1,850	Na+K 16	See Na	650	52	79	—	308	1,450	2,700		2	0.2
5	Dist. No. 5 Main Trunk, Sepulveda Blvd.	—	—	365	Na+K 340	See Na	68	47	650	—	190	320	1,600		—	1.4
6	Dist. No. 5 Main Trunk, 182nd & Arlington	—	—	200	Na+K 150	See Na	47	20	120	—	350	85	850		60	0.5
	Effluents From Sewage Treatment Plants															
7	El Monte	—	—	280	Na+K 80	See Na	80	20	80	31	290	60	570		39	0.6
8	Whittier	—	—	200	Na+K 90	See Na	60	12	90	80	125	60	540		51	0.5
9	Covina	—	—	180	Na+K 100	See Na	—	—	180	55	70	50	570		55	0.1
10	Redwood City	6.8	428	—	654	—	76	67	1,000	—	524	41	2,330		75	0.9
11	San Mateo	7.1	448	—	310	—	40	45	355	—	547	10	1,480		70	0.4
12	San Francisco, Richmond Sunset	7.2	240	147	134	—	25	11	95	—	268	26	526		73	0.6
13	San Leandro	7.1	328	—	246	—	33	23	242	—	400	36	920		74	0.5
14	Palo Alto	7.1	340	—	197	—	26	16	145	—	415	16	780		77	0.5
15	Bakersfield	7.7	229	120	245	—	41	4	46	—	279	171		70.51	82	—
16	San Diego	7.0	—	320	500	—	40	50	710	1.0	360	110	1,600		77	0.9
17	Oxnard	7.2	—	—	237	15	162	56	203	33	281	545	1,200		44	0.86
18	Orange County, Joint Outfall Sewer§	—	—	—	Na+K 95	See Na	82	28	100	1.9	181	228	—		39	—
19	Pomona	—	—	—	79	—	40	9	77	1.73	173	29		73.6	56	1.46
20	Corona	—	—	—	130	—	81	12	71	0.29	422	80		115	53	1.05
21	Riverside	—	—	—	63	—	26	59	77	—	378	29		88.2	30	2.80
22	San Bernardino	—	—	—	80	—	54	11	71	—	259	38		74.2	49	0.17
23	Redlands	—	—	—	144	—	42	12	75	—	417	20		95.6	67	7.70
	Raw-Untreated Sewage															
24	San Bruno and South San Francisco	8.9	468	—	218	—	35	31	127	—	395	41	900		68	0.2
25	Southeast San Francisco	6.8	252	—	128	—	18	15	95	—	308	Trace	500		72	0.6
26	North Plant, San Francisco	7.0	248	139	203	—	25	18	196	—	302	52	910		77	1.4
27	Azusa	—	—	—	61	12	108	22	62	0.1	369	20	600		27	0.5
28	Los Angeles	7.4	304	220	226	—	54	23	219	—	370	124	903		70	—
29	San Jose	—	—	317	Na+K 281	See Na	76	31	409	—	293	106	1,960		66	0.33

TABLE 2—*Continued*

Index No.*	Source	pH	Alkalinity $CaCO_3$ *ppm*	Total Hardness $CaCO_3$ *ppm*	Cations: Sodium Na^+ *ppm*	Cations: Potassium K^+ *ppm*	Cations: Calcium Ca^{++} *ppm*	Cations: Magnesium Mg^{++} *ppm*	Anions: Chloride Cl^- *ppm*	Anions: Nitrate NO_3^- *ppm*	Anions: Bicarbonate HCO_3^- *ppm*	Anions: Sulfate $SO_4^=$ *ppm*	Dissolved Solids *ppm*	Dissolved Solids $K \times 10^5$†	Proportion Sodium‡ *per cent*	Boron *ppm*
	Domestic Water Supplies															
30	Metro. Water Dist. of So. Calif., Unsoftened	—	—	344	Na+K 116	See Na	85	32	91	0.3	145	333	737		41	0.1
31	Metro. Water Dist. of So. Calif., Softened	—	—	130	Na+K 195	See Na	29	14	98	0.3	57	333	724		75	0.1
32	Los Angeles, Owens Valley	—	—	99	Na+K 45	See Na	28	7	21	0.02	183	26	234		47	0.69
33	Los Angeles, Van Owens Wells	—	—	178	Na+K 30	See Na	49	13	17	1.7	183	65	281		26	0.1
34	Los Angeles, Los Angeles River	—	—	300	Na+K 58	See Na	80	23	36	11	246	159	508		29	0.23
35	Long Beach, No. Signal Hill	—	—	40	Na+K 70	See Na	14	1	23	Trace	93	7	281		75	0.2
36	Montebello Water Co.	—	—	232	Na+K 44	See Na	70	14	49	—	262	41	487		29	Trace
37	Downey Company Water Dist.	—	—	215	Na+K 20	See Na	65	13	14	—	252	30	450		17	—
38	Manhattan Beach	—	—	230	Na+K 65	See Na	57	21	100	—	245	29	—		38	—
39	Lomita	—	—	153	Na+K 163	See Na	50	6	130	—	386	4	—		70	—
40	San Francisco	—	53	60	26	—	15	6	8	—	—	12	—		46	—
41	East Bay Municipal Utilities Dist.	—	18	18	2	—	6	0.8	3	—	—	1	—		18	—
42	San Diego	—	164	124	54	—	32	12	48	—	—	21	—		47	—
43	San Jose, Deep Wells	—	202	212	33	—	56	21	23	—	—	32	—		21	—
44	San Bernardino	—	131	126	40	—	43	5	12	—	—	41	—		40	—
45	Oxnard	—	224	559	133	—	130	59	70	—	—	511	—		33	—
46	Anaheim	—	202	125	88	—	33	8	50	—	—	36	—		62	—
	Irrigation Water Supply															
47	Yakima River, Sunnyside Project	7.6	—	—	6	1.5	11	4	5	Trace	61	3		11.7	23	0.02
48	Sacramento River at Tisdale	7.9	—	—	6	1.5	12	6	4	Trace	74	6		15.0	18	0.05
49	Columbia River at Wenatchee, Wash.	7.0	—	—	4	—	18	5	2	Trace	77	10		15.1	13	0.05
50	Yellowstone River at Huntley, Mont.	7.5	—	—	14	0	18	7	4	2	72	25		19.1	29	0.06
51	No. Platte River near Scotts Bluff, Neb.	7.5	—	—	15	2.7	32	7	3	2	97	54		28.0	22	0.03
52	Cache Creek at Capay Dam, Calif.	—	—	—	41	—	26	29	37	Trace	206	29		50.8	32	1.78
53	San Joaquin River near Vernalis, Calif.	7.0	—	—	88	6.2	36	19	37	3	152	187		76.4	52	0.18
54	Arkansas River, Pueblo Co., Colo.	8.2	—	—	61	8.2	101	32	17	Trace	165	354		93.3	25	0.08
55	Rio Grande at El Paso, Tex.	8.3	—	—	133	8.2	83	18	107	2	203	238		112	50	0.20
56	Colorado River at Yuma, Ariz.	7.8	—	—	108	—	101	28	82	2	154	344		117	39	0.16
57	Gila River at Ashurst-Hayden Dam, Ariz.	—	—	—	178	9.8	68	19	251	1	168	110		133	60	0.20
58	Pecos River near Orla, Tex.	—	—	—	293	23.8	501	152	951	0	81	1,710		542	40	0.37

* Index numbers indicate fresh or reclaimed waters shown in Fig. 4 and 5.
† $K \times 10^5$ means conductivity in mhos per cm times 10^5.
‡ Ratio of sodium to the total cations expressed in equivalent weights. Calculated from the formula $\frac{Na \times 100}{Na + K + Ca + Mg}$.
§ Mineral content of waters corrected to that which will be reclaimed—that is, objectionable industrial wastes excluded.

TABLE 3

Typical Chemical Analysis of Lodi Sewage Effluent and Soil Percolate

Effluent Concentration	Cations—*ppm*					Anions—*ppm*						Closure error *per cent*	Organic N
	NH_4^+	Na^+	K^+	Ca^{++}	Mg^{++}	NO_3^-	NO_2^-	PO_4^-	SO_4^-	Cl^-	HCO_3^-		
ppm	10.6	62	10.5	32	20	24.2	0	4.6	26	64	180	7.7	3.3
Depth—*ft*													
1	0	41	6.6	33	26	40.0	0	0.28	22	59	174	1.0	1.9
2	0	52	3.8	43	18	55.0	0	0	31	56	180	0.7	1.1
4	0	65	4.1	28	11	36.2	0	0	26	62	168	3.6	2.0
10	0	59	4.3	41	17	68.0	0	0.11	43	47	200	3.8	4.2
13	0	59	3.9	40	16	46.6	0	0	35	53	221	4.8	2.1

San Joaquin Valley. Although scarifying had no effect on percolation rates there, the addition of organic material in the form of cotton gin trash, plus turning of the soil, increased the percolation rates tremendously. Rates as high as 14 acre-ft per acre per day have been noted, with an overall average for the treated plots of 3 to 4 acre-ft per acre per day. The average rate of untreated plots was 0.5 to 1 acre-ft per acre per day.

The results of the Kern County studies indicate that the addition of materials that increase the soil aggregate size also increases the percolation rates. Grasses grown on the Kern County percolation ponds have increased percolation rates to nearly the same level as that of the plots treated with cotton gin trash. At Lodi, some aggregation is probably taking place as a result of the organic material present in the treated sewage. An investigation to study the effects of sewage irrigation on crops, and the effects of crops on sewage infiltration was begun recently at the University of California at Los Angeles.

Reclaimed Water Quality

Permissible concentrations for various chemical constituents in irrigation water for various types of soils and crops have been determined by agriculturists and soil scientists (15–18). Table 1 gives the generally accepted permissible limits. Table 2 gives data on the major chemical constituents of domestic water supplies and sewages from 58 localities. Some of these waters and sewages are compared chemically in Fig. 4 and 5.

Figure 4 classifies the waters according to their dissolved solids and sodium concentrations into excellent, good, permissible, doubtful, and unsuitable groups. Only four waters fall in the doubtful or unsuitable groups, and if brines and other industrial wastes had been segregated, these waters would probably have been classed as satisfactory.

Boron concentrations of the waters in Table 2 are shown in Figure 5 for the five classifications of irrigation water and three groups of plant sensitivity. Only two of the waters contain boron concentrations which fall in the unsuitable classification. These concentrations are toxic for the boron-sensitive plants only. All waters classify as permissible or better for the semitolerant and tolerant plants.

In a study at Lodi, activated sludge plant effluent was spread on plots de-

TABLE 4

*Estimated Total Annual Cost Per Unit of Reclaimed Water in Los Angeles County**

Location of Proposed Water Reclamation Plant	Proposed Use of Reclaimed Water	Plant Capacity *mgd*	Total Annual Cost Per Acre-Ft—*dollars*†			
			1st Year	26th Year	50th Year	50-Year Average
Below Whittier Narrows	Spreading on Rio Hondo Spreading Grounds	10	19.05	16.40	13.80	16.40
Below Whittier Narrows	Spreading on Rio Hondo Spreading Grounds	50	—	—	—	14.20
Adjacent to L.A. County Sanitation Dists. Joint Disposal Plant	Spreading grounds east of Redondo Beach	10	21.80	18.00	14.40	18.00
Adjacent to L.A. County Sanitation Dists. Joint Disposal Plant	Percolation beds along north rim of Palos Verdes Hills	10	23.00	19.05	15.20	19.05
Tri-CitiesActivatedSludge Plant‡ (existing but unused)	Rio Hondo River Channel	8	10.00	9.30	8.60	9.30
Near 223rd & Wilmington Avenue	Industrial use (oil refineries)	10	23.10	19.00	15.00	19.00

* Summarized from report on "Reclamation of Water from Sewage and Industrial Wastes in Los Angeles County, Calif.," April 1949, by C. E. Arnold, H. E. Hedger, and A. M. Rawn.

† Total annual costs per acre-ft include principal and interest on land, structures, equipment, pumping plants, pipelines, and engineering, contingencies, and operation costs of water reclamation plant, pumping, spreading or other uses, and overhead. Annual capital costs are based on 50-yr serial bonds at 4 per cent interest. Operation costs assume operation 95 per cent of the time.

‡ Costs include allowances for purchase of existing plant and plant revisions.

signed to sample the percolate at various depths below the ground surface. Table 3 shows a typical chemical analysis of the percolate at different depths. These data show that there were no appreciable changes in the cations except for the ammonium ion which was completely removed in the first foot of travel through the soil. Significant changes in the anions were found only in the phosphate and nitrate-nitrogen ions. Phosphate, like ammonium, was almost entirely removed in the first foot of soil. Nitrate-nitrogen increased with depth in the biologically active zone (peak at 10 ft) and then decreased. Organic nitrogen, after an initial decrease, reached a peak at about the 10-ft depth. The nitrate-nitrogen was the only constituent which might be considered a contaminant; its significance, however, would be reduced greatly by dilution in the ground water basin. Dissolved oxygen reached a minimum at the 1-ft depth, increased to a maximum at 7 ft, and then decreased with depth, but was not depleted at 13 ft. The BOD of the plant effluent was low—10 to 12 ppm. The BOD of the percolate collected at depths of 1 ft and more was 2 ppm.

Bacteriologically, the percolated sewage effluent met the U.S. Public Health Drinking Water Standards after traveling a vertical distance of only 1 ft. The most probable number (MPN) of the coliform group organisms in the plant effluent ranged from 10,000 to 100,000 per 100 ml. During the first year, positive samples never occurred at depths greater than 1 ft and the calculated most probable number for a large series of samples was less than 0.5

TABLE 5

Wholesale Cost of Fresh and Reclaimed Water

Type of Water Supply	Source of Water	Cost Per Acre-Ft—*dollars*[1]	Reference No.
	Metropolitan Water District of Southern California[2]	20	24
	Production, exclusive of interest and bond redemption[3]	12	24
	Interest and bond redemption	8	24
Fresh	Los Angeles (Aqueduct Water)[4]	19	25
	Cost exclusive of interest on investment in lands	15	25
	Interest on investment in lands	4	25
	Raymond Basin Exchange Water[5]		
	Average cost for 11 parties in Western Unit	29	26
	City of Pasadena	34	26
Water	Average cost for 10 parties; Pasadena not included	20	26
	East Bay Municipal Utility District (Mokelumne River Water[6]	40	27
	San Francisco City and County[7]		
	Large individual consumers	59	28
	South peninsula cities and companies buying water for resale	70	28
Supplies[8]	California Central Valley Project[9]		
	City of Richmond	17	29
	City of Vallejo	14	29
	Domestic Water—Retail[7]		
	Range of U. S. cities	30–80	30
	Distillation		
	Vapor compression	400–500	24
Sea	Vapor compression	67–100	31
	Vapor compression	208	32
Water	Multiple-effect evaporator, 5 effects	160	33
		8,000	24
Reclamation[10]	Anion and Cation Demineralizer (chemicals only)		
	Electrolytic Process (power only)	293	24
		400	24

[1] Cost figures have been taken to nearest dollar. For sea water and waste water reclamation, costs have been estimated by various engineering groups (see reference numbers).

[2] Cost of softening and filtering the supply for domestic use, which is approximately $10.00 per acre-ft, is not included in the $20.00 figure.

[3] It is estimated that the production cost, exclusive of interest and bond redemption, will ultimately decrease from $12.00 to $8.00 per acre-ft.

[4] The costs are related to the rated capacity of the aqueduct, 319,000 acre-ft per year. They are based on interest at 4 per cent and on an expected life of 67 yr for the principal aqueduct structures.

[5] Undue costs amounting to approximately $1.32 per acre-ft have not been included in the average figures.

[6] The cost is a weighted average based on quantity of water delivered and total cost for the years 1930–31, 1934–35, 1939–40, and 1944–45.

[7] Costs include distribution to the consumer.

[8] Most of the fresh-water supplies are imported, although some well-water supply costs are included in the Raymond Basin Exchange Water figures.

[9] Estimated costs for raw water at canal site.

[10] Costs for reclamation of sea water have been taken from Table 9, where they are also expressed in cost per 1,000 gal and cost per mil gal.

TABLE 5—*Continued*

Type of Water Supply	Source of Water	Cost Per Acre-Ft—*dollars*[1]	Reference No.
	Los Angeles County		
Waste	New reclamation plants[11]	16	11
	Existing, but inactive, reclamation plant (activated sludge)[12]	9	11
Water			
	Santa Clara Water Conservation District[13]	16–19	12
Reclamation	Orange County[14]	20	23

[11] Cost, which is estimated average over 50-yr period, is based on activated sludge plant of 10-mgd capacity, 50-yr serial bonds, 4 per cent interest, and assuming operation 95 per cent of time. Cost is typical for the many other alternates which are considered in the report. The breakdown of the average cost of $16.00 per acre-ft is given in Table 8.

[12] Cost, which is estimated average over 40-yr period, is based on existing activated sludge plant of 8-mgd capacity, 50-yr serial bonds, and 4 per cent interest.

[13] Cost, which is estimated average over 40-yr period, is based on 40-yr serial bonds and 3 per cent interest.

[14] Cost, which is estimated average over 40-yr period, is based on activated sludge plant of 51-mgd capacity, 40-yr serial bonds, and 2 per cent interest. It includes pumping plants, force mains, and pipes necessary for distribution of the reclaimed waters on agricultural lands.

organisms per 100 ml. at the 1-ft depth. During the second year, however, coliform organisms were observed occasionally at the 2-ft depth and only rarely at the 4-ft depth.

The public health significance of sewage irrigation of those fruits and vegetables which are to be eaten raw has been questioned somewhat in recent publications (19–21). The most recent studies of Rudolfs, Falk, and Ragotzkie (22) on the contamination of vegetables grown in polluted soil showed that, if sewage irrigation is discontinued one month before harvest, fruit, if eaten raw, is probably not an important avenue for the transmission of human enteric diseases.

Cost of Alternative Methods

Other sources of water with which to augment the water supply are available to water-shortage areas. These sources include the reclamation of fresh water from sea water, the construction of aqueducts to watersheds having a surplus of water, and possibly, controlled rainmaking through cloud seeding.

Recovery of fresh water from sea water is an expensive method of producing a supplemental water supply. Fresh water production from sea water has been used only for military needs, with costs a secondary consideration, or for certain remote arid regions where the consumption of fuel to obtain water can be justified.

In Los Angeles County, it is estimated that reclaimed water from works specially constructed to supplement existing sewage disposal facilities would cost from $16 to $20 per acre-ft, including both treatment and spreading. Details of the estimated annual costs for the projects studied are given in Table 4. These costs include capital, operation, and maintenance charges for all works required, in addition to those already in use by the county. The Santa Clara Water Conservation District (12) in Ventura County has found that a similar project for the city of Ventura, using natural percolation beds at Saticoy, would cost from $16 to $19 per acre-ft of reclaimed water. In the Orange County Sewerage Survey (23), the engineers

estimated that water could be reclaimed by further treating the primary effluent by the activated sludge process at a cost of $20 to $35 an acre-ft. The reclaimed waters were to be used for irrigating orchards and other agricultural lands.

The above costs, the cost of demineralizing sea water, and the cost of present fresh water supplies have been tabulated in Table 5. These data demonstrate conclusively that reclaimed waters from sewages are economically competitive with other water supplies. Within limits the cost is less, or no more, than for imported natural supplies, and considerably less than for sea water reclamation.

Conclusions

Recent and past studies have demonstrated that water usable for domestic, industrial, agricultural, and other purposes can be reclaimed from sanitary sewages and many industrial wastes. The processes necessary for the reclamation of water are essentially those used for sewage disposal and water purification. Reclamation works designed for water production would make maximum use of the local sewage disposal facilities. Only the cost of the additional works may be considered as the real cost of planned reclamation projects; the costs of incidental reclamation are usually borne only in part, or not at all, by the water consumer. The cost of water reclamation has been shown to be competitive with other sources of supplemental water, and frequently is less.

All areas in need of water will not reclaim water from sewage because wastes may contain deleterious materials, or the locale may not provide the necessary spreading grounds or consumers. The quality of water which may be reclaimed from many sewages is satisfactory for replenishing ground water sources. Many regions could profit greatly by utilizing the water now discharged and wasted as sewage.

Acknowledgment

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External Loads on Pipe With Cement Mortar

By H. L. White

A paper presented on Oct. 24, 1951, at the California Section Meeting, San Francisco, by H. L. White, Chief Engr., American Pipe & Construction Co., Southgate, Calif.

THE past fifteen years have witnessed the development and widespread use of a new type of thin-walled concrete cylinder pipe. The developer of this type of pipe has named it American Concrete Cylinder Pipe, but it is now commonly known in the West as modified prestressed-concrete cylinder pipe. Its development and use have roughly paralleled a renewed and extended use of cement-mortar-lined and -coated steel pipe in both small and large diameters. Both modified prestressed-concrete cylinder and mortar-lined and -coated steel pipe must be considered semirigid. The reaction of semirigid pipe to overload differs somewhat from that of rigid and so-called flexible pipe. Although the engineering literature contains many discussions of the external-load-carrying ability of both rigid and flexible classes of pipe, few investigations of the newer, semirigid pipe have been reported.

A semirigid pipe resembles a flexible pipe in that it will deflect from external loads and obtain some supporting strength from the lateral pressure of the soil at the sides of the pipe, but the mortar lining and coating, acting like a rigid pipe, impart an inherent strength to the pipe to withstand external loads. Spangler (1) has reviewed the research on underground conduits and states that the deflection—the cause of failure—of a flexible pipe can be determined within close limits by using present theory, but that rigid pipes, because they fail by rupture of the wall, are best tested in the laboratory to determine load-carrying capacity. The factor limiting the safe use of semirigid pipe is the amount of deflection which may be permitted in the steel before harmful cracks, which would impair the protective qualities of the cement-mortar lining and coating, appear. Like rigid pipe, semirigid pipe does not lend itself to strict mathematical analysis but can be tested in the laboratory.

Because of the need for data on the characteristics of mortar-lined and -coated steel pipe, a series of external load tests were conducted. These tests had a twofold purpose: [1] to provide information on the ability of lined and coated steel pipe to carry external loads; and [2] to demonstrate the advantage of placing part of the required cross sectional steel area of a steel pipe in a circumferential rod reinforcement wound under measured tension rather than having all of the effective steel area in the cylinder.

Pipe Designs

The tests were conducted on three designs of pipe which had equal steel areas. The three designs (Fig. 1) are: Type A—a cement-mortar-lined and -coated pipe in which the required

TABLE 1

Description of Pipe Species

Pipe Size *in.*	Specimen No.	Type	Total Steel Area*	Cylinder		Rod Reinforcement			Coating		Lining Thickness *in.*
				Thickness *gage*	Steel Area*	Coils per Lin Ft	Size	Steel Area*	Thickness *in.*	Wire Mesh†	
21	1a, 1b	A	1.61	14	0.90	9.25	5/16 in.	0.71	1	—	3/4
	2a, 2b	B	1.61	10	1.61	—	—	—	1	2/4–13/13	3/4
	3a, 3b	C	1.61	10	1.61	—	—	—	—	—	—
30	1a, 1b	A	1.61	12	1.26	10.4	No. 5	0.35	1	—	3/4
	2a, 2b	A	2.25	12	1.26	8.95	3/8 in.	0.99	1	—	3/4
	3a, 3b	A	2.25	10	1.61	8.35	5/16 in.	0.64	1	—	3/4
	4a, 4b	A	1.61	15	0.81	10.3	5/16 in.	0.80	1	—	3/4
	5a, 5b	B	1.61	10	1.61	—	—	—	1	2/4–13/13	3/4
	6a, 6b	B	2.25	3/16‡	2.25	—	—	—	1	2/4–13/13	3/4
	7a, 7b	C	1.61	10	1.61	—	—	—	—	—	—
	8a, 8b	C	2.25	3/16‡	2.25	—	—	—	—	—	—
36	1a, 1b	A	1.61	12	1.26	10.4	No. 5	0.35	1	—	3/4
	2a, 2b	A	2.25	10	1.61	8.35	5/16 in.	0.64	1	—	3/4
	3a, 3b	B	1.61	10	1.61	—	—	—	1	2/4–13/13	3/4
	4a, 4b	B	2.25	3/16‡	2.25	—	—	—	1	2/4–13/13	3/4
	5a, 5b	C	1.61	10	1.61	—	—	—	—	—	—
	6a, 6b	C	2.25	3/16‡	2.25	—	—	—	—	—	—

* Cross-sectional area in square inches per lin ft of one pipe wall.
† 2/4–13/13 means a 13-gage wire mesh with a spacing of 2 by 4 in.
‡ Cylinder thickness in inches.

cross-sectional steel area is distributed between a light-gage steel cylinder and circumferential reinforcement rods wound around the cylinder under measured tension; Type B—a cement-mortar-lined and -coated steel pipe having all the required steel area in the cylinder; and Type C—a bare steel pipe with all of the steel in the cylinder. For every specimen in which mortar lining and coating were used, the mortar, within manufacturing tolerances, was held to the same depth.

These tests were conducted on specimens approximately 8 ft long. The diameters and steel areas are given in Table 1. Although the tests were conducted under simulated trench conditions, the results are applicable only to an identical trench condition and not to the many other types of trench conditions encountered in field work. The test was not all-inclusive; but it did show that the Type A design was definitely superior to Type B in resistance to external loads.

Pipe Manufacture

The pipes were manufactured under similar conditions and in accordance with the specifications given in Table 1. All the cylinders were manufactured from commercial grade steel (ASTM A-245), and were subjected to a hydrostatic test which stressed the steel to 22,000 psi, thus assuring a uniform test of the strength of the three longitudinally welded seams of each speci-

men. After the cylinders for the Type A pipe were fabricated, a centrifugal lining was spun in the cylinders and was allowed to cure for three days under a water spray. The concrete-lined steel cylinders were then circumferentially wound with steel rods (ASTM A-15) which were under a measured tension of approximately 10,000 psi. The pipe was then given a machine application of cement-mortar coating. The cylinders for Type B were made in a similar manner except that all of the steel was in the cylinder and no rod reinforcements were added. A centrifugal mortar lining was spun in the cylinder. After the lining had cured for three days under a water spray, a 2- × 4-in. 13-gage wire mesh was wrapped around the cylinder and a machine-applied cement-mortar coating was added. The steel area of the wire mesh was not included in the design area of steel for the Type B pipe. Before the pipe specimens were tested, all the cement mortar reached the 28-day strength. Type C pipe was a bare steel cylinder manufactured and tested by the same procedure as was used for the other cylinders.

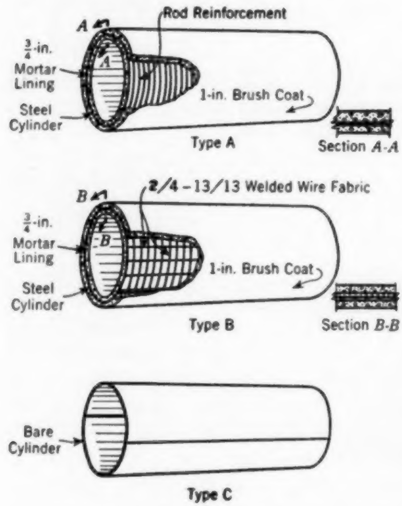

Fig 1. Pipe Designs

Type A is a cement-mortar-lined and -coated steel pipe with the required cross-sectional steel area distributed between the steel cylinder and circumferential reinforcement rods. Type B is a cement-mortar-lined and -coated steel pipe with all the required steel area in the cylinder. Type C is a bare steel pipe with all the steel in the cylinder.

Fig. 2. Testing Apparatus

The pipe was placed in 6 in. of sand, parallel to the beam applying the load.

Testing Procedure

The method and the apparatus for testing were similar to the procedure established by Talbot (2).

The load-carrying ability and distribution of bending moments on different parts of the pipe depend on a number of factors, the most important of which are the type of soil used in backfilling.

the method of bedding the pipe, and the method of compacting the backfill. To obtain comparable results, every effort was made to keep these factors constant. Before a test specimen was placed in the box shown in Fig. 2, approximately 6 in. of sand was placed on the box floor. The pipe was then placed in a level position in the sand parallel to the beam applying the load. Before backfilling was begun, two mi-

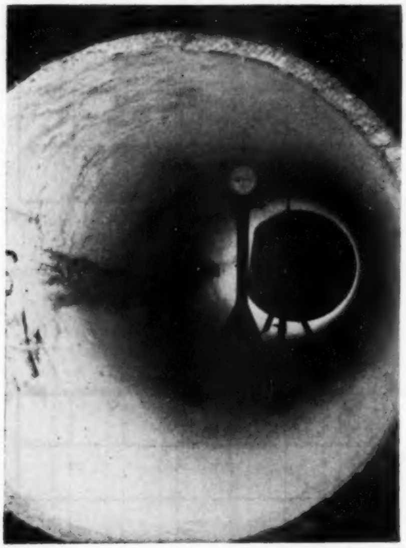

Fig. 3. Micrometer Dial Indicators

The indicators were placed 2 ft from either end of the pipe.

crometer dial indicators were placed 2 ft from either end of the test specimen, as shown in Fig. 3. Sand was then lightly tamped about the pipe to the lower quarter point. Above the quarter point, the sand backfill was added in layers of approximately 6 in. After each layer was added, the sand was soaked with water to obtain proper compaction. Backfilling was continued 2 ft above the pipe surface for each specimen. Because of the homogeneity of the trench floor and the backfill material the trench bedding is designated Class B under the definition of the American Concrete Pipe Assn. (3).

After the pipe had been completely backfilled, indicator readings showing only the backfill deflection were taken.

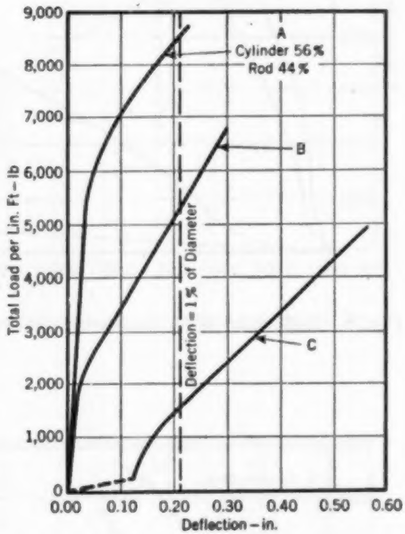

Fig. 4. Deflection With Increasing Load for Three Pipe Designs

Steel pipe 21 in. in diameter and equivalent to No. 10-gage sheet steel was used for all three types. The letters A, B, and C on the figure refer to the type pipe being tested.

A load was then applied in increments of 880 lb per lineal foot of specimen (250 increments on the gage). Gage readings were noted in increments of 50 in order to obtain an accurate record of the size and location of cracks in the mortar lining. The indicator readings and the results of these tests are given in Figs. 4–8. The results for

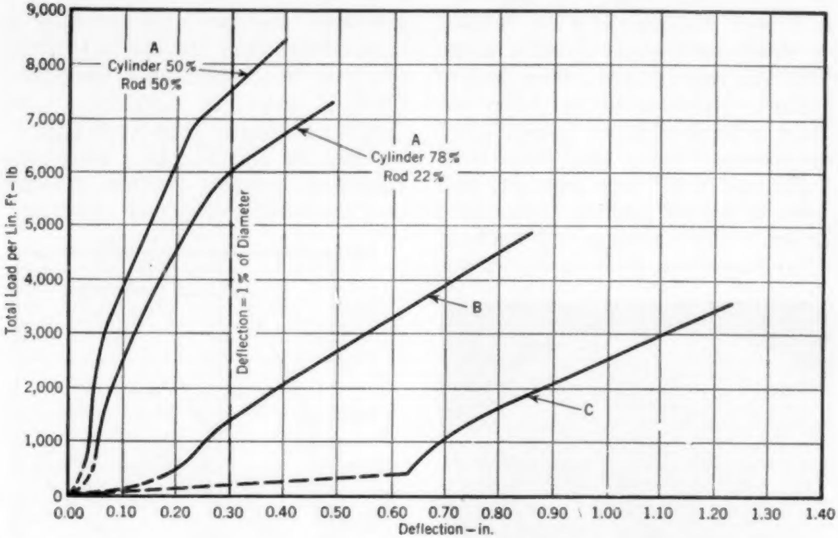

Fig. 5. Deflection With Increasing Load for 30-in. Diameter, No. 10-Gage Sheet Steel

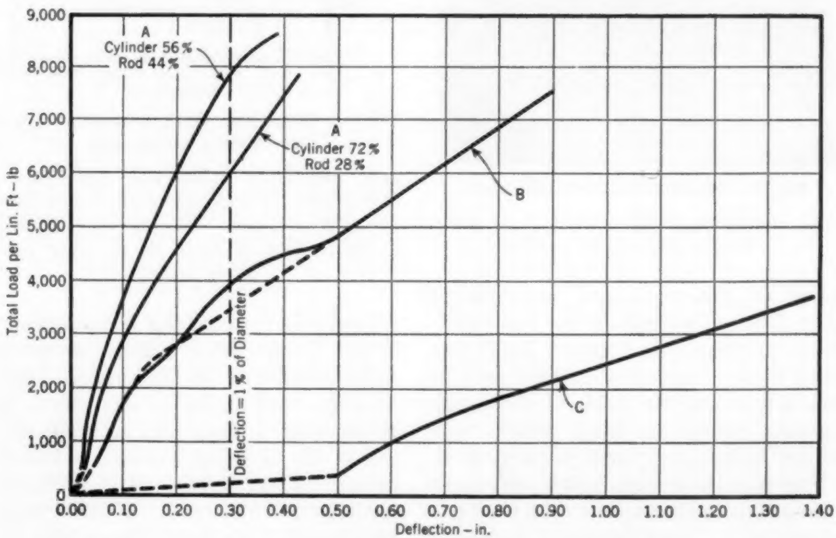

Fig. 6. Deflection With Increasing Load for 30-in. Diameter $\frac{3}{16}$-in. Plate Steel

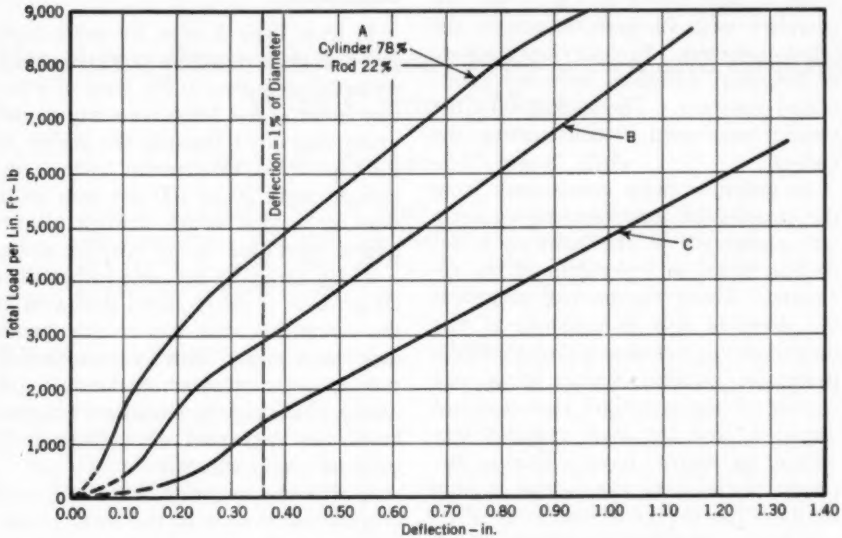

Fig. 7. Deflection With Increasing Load for 36-in. Diameter, No. 10-Gage Sheet Steel

Fig. 8. Deflection With Increasing Load for 36-in. Diameter, $\frac{3}{16}$-in. Plate Steel

Type B pipe shown in Fig. 5 did not correlate with its performance in the other diameters. Probably one or more of the many variables were not maintained constant. The averages of the results were used in constructing the curves.

In order to draw conclusions from the curves, the load carrying capacity was compared on the basis of a deflection equal to 1 per cent of the diameter. There was no real precedent for selecting this percentage; it was chosen simply because at that point the protective quality of the lining and coating of the semirigid pipe was not impaired, and the steel cylinder was within its elastic limit. During the course of the tests, the mortar coating on the Type B pipe in diameters of 30 and 36 in. cracked, as the load was applied, and separated from the steel cylinder so that light could be seen at the spring line. When the load was removed and the specimens were uncovered, however, the coating was still intact although cracks in the specimens were visible. This separation of the concrete and the steel cylinder was not apparent in the Type A pipe at any recorded external loading. It was possible to examine the coating only at the ends of the pipe, but construction was identical for each specimen. Although placing part of the required steel of the Type A pipe in a circumferentially wound rod reinforcement increases the section modulus, the resulting increased capacity for carrying external loads cannot be attributed to this fact alone. It becomes apparent that the spirally wound rod reinforcement affords a keying action which binds the mortar coating to the steel and makes them act together in resisting external loads.

Conclusions

1. In a Type A pipe, by using from 20 to 40 per cent of the required cross-sectional steel area in the form of a circumferential rod reinforcement, wound under measured tension, the ability of the pipe to carry external loads is increased from 50 to 100 per cent more than in a pipe which utilizes all required steel area in the cylinder alone.

2. By using 50 per cent rather than 20 per cent of the required steel area in the circumferential rod reinforcement of Type A pipes (with a corresponding reduction in cylinder thickness), the ability of the pipe to withstand external loads was increased an additional 25 per cent, approximately.

3. The placement of part of the total required steel area in the form of circumferentially wound rod reinforcement provides a mechanical lock which prevents separation of the mortar coating from the steel cylinder and makes them act in unison in resisting external cover loads.

Acknowledgment

These tests and the resulting data were conducted and prepared under the supervision of L. W. Irwin, Director of Research and Development, American Pipe and Construction Co., and were observed by John G. Hendrickson Jr., Research Engr., American Concrete Pipe Assn.

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Crushing Strength of Steel Pipe Lined and Coated With Cement Mortar

By Leslie Paul and Owen F. Eide

A paper presented on Oct. 24, 1951, at the California Section Meeting, San Francisco, Calif., by Leslie Paul, Supervising Mech. Elec. Engr., and Owen F. Eide, Asst. Mech. Elec. Engr., East Bay Municipal Utility Dist. Oakland, Calif.

IN designing the 48-in. Sequoia Aqueduct Extension, a part of the distribution system to be installed in Oakland, Calif., the East Bay Municipal Utility Dist. desired to keep the number of vacuum valves as small as possible. These valves are required to prevent vacuum collapse of any thin-walled, large-diameter pipe if the internal pressure falls far enough below atmospheric to produce a critical external pressure.

Although a wealth of engineering data on bare steel pipe is available, a search of engineering literature indicated that little is known about the extent to which a portland cement-mortar interior lining or a portland cement-mortar exterior coating will strengthen steel pipe against collapsing from external pressure. It was decided, therefore, to test a typical section of the pipe to be installed.

All but one of the mathematical formulas developed to explain the collapse of long pipelines from external pressure apply to pipe of indefinite length with free ends or ends held circular by reinforcing rings but not otherwise constrained. The one exception is a theoretical formula for the collapsing pressure of a cylindrical shell with closed ends under external end load as well as circumferential load, developed by von Mises in 1914, and noted by Saunders and Windenberg (1) and Roark (2). This formula was used to compare theoretical values with the experimental results.

Experimental Procedure

The first experiments were performed on a 49-in. ID steel pipe with a wall thickness of $\frac{1}{4}$ in. This pipe had a $\frac{1}{2}$-in. thick centrifugally spun cement-mortar lining, making a net internal diameter of 48 in. A coating reinforcement of $\frac{1}{4}$-in. round steel wire was spiral wound around the pipe at 2-in. coil spacing and an initial tension of 5,000 psi. The exterior of the pipe was then brush coated with a $\frac{3}{4}$-in. thickness of cement mortar. Three 30-ft lengths of this pipe were welded together and bulkheads were welded to the outer ends in order to make an assembly 90 ft long. The pipe joints were of bell-and-spigot type with $\frac{1}{4}$-in. fillet welds inside and outside. The $\frac{3}{8}$-in. thick bulkheads were butt welded to the pipe. Taps were made so that a vacuum pump could be installed on one end of the assembly and the instruments on the other end. The instruments consisted of one recording vacuum gage (0–30 in. mercury) with a

60-min chart drive and one mercury manometer, both calibrated to read in inches of mercury. Figure 1 shows the arrangement of the test specimen in the trench with the backfill in place.

The assembly was made in the bottom of a ditch excavated in well drained, sandy soil. After lining up and welding the component parts, the assembly was filled with water and held under 65 psi pressure in order to maintain the pipe in as round a condition as possible until an imported sand backfill could be placed. The backfill was then completed to a depth of 3 to $4\frac{1}{2}$ ft above the top of the pipe. It was hoped that, if the portland cement-mortar applications added no strength to the pipe, there might be some indication of the influence of the backfill in strengthening the pipe against collapse.

The pipe was drained of water and the vacuum pump was started and operated until the pressure reached 27.19 in. of mercury, or 13.35 psi external pressure, as near a vacuum as the equipment could attain.

As the pipe failed to collapse the experiment was repeated, first with the backfill removed, then with the cement-mortar coating removed from the center 30-ft section, and next with the cement-mortar lining removed from this section. When it was realized that the cement-mortar coating and lining strengthened the pipe beyond any value which had previously been suspected, the lining and the coating were removed from the pipe. A small section of coating under the pipe, but in which the pipe was cradled, was loosened from the pipe but not removed.

The vacuum pump was again started, and as the vacuum in the pipe increased there were indications that this time the pipe might collapse. As the air was exhausted and the mercury column and gage showed a vacuum of 20 in. of mercury, the pipe began to emit crackling sounds and to give slight manifestations of writhing in the remaining cement coating in which it was cradled. As the vacuum increased the crackling noise and the writhing

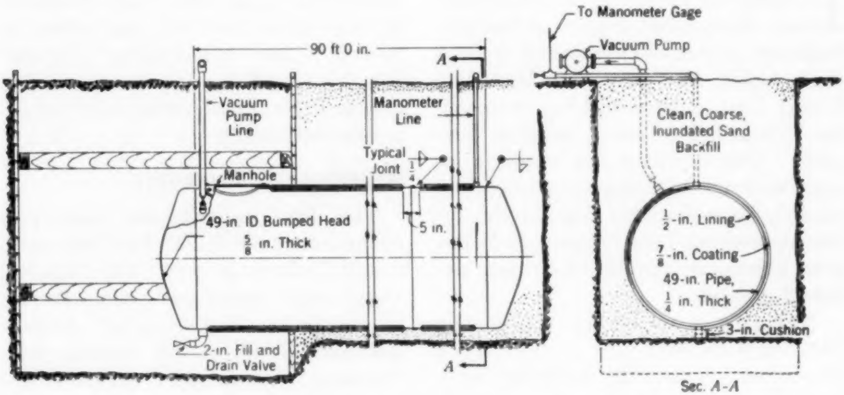

Fig. 1. Arrangement of Steel Pipe in Trench

The pipe has an inside diameter of 49 in. and a wall thickness of $\frac{1}{4}$ in.

became more pronounced. The pipe flattened into an elliptical instead of a round section, and tried to climb out of the cradle in which it rested. When the vacuum reached 24.34 in. of mercury, or an external pressure of 11.95 psi, the pipe suddenly collapsed with an implosive effect disturbing to neighbors within a radius of about four blocks. The field result of 11.95 psi closely checked the calculated collapsing pressure of 11.40 psi, as derived from the von Mises formula for bare steel pipe. Figure 2 shows the center

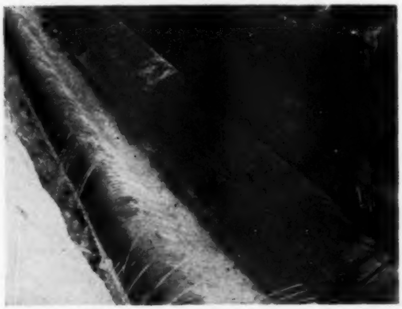

Fig. 2. Center Section of Collapsed 49-in. Pipe

The pipe collapsed at an external pressure of 11.95 psi.

section of the pipe, where collapse began.

The pipe had finally collapsed, the reliability of the von Mises formula was indicated, and the strengthening of bare steel pipe against collapse from external pressure by cement mortar coatings and linings was established, but the extent to which the coatings and linings strengthen the bare steel pipe was not known.

In order to proceed with the next step in the experiment, the collapsed pipe had to be repaired. The pipe was filled with water through a fire hose connected to a nearby hydrant. Figure 3 shows the pipe gradually coming back to some semblance of its original shape as a result of filling with water. The application of the full hydrant pressure of 65 psi brought the

Fig. 3. Collapsed Pipe Being Filled With Water

A fire hose connected to a nearby hydrant was used. The pipe regained its original shape at a hydrant pressure of 65 psi.

pipe back to its original shape. The pipe was then stressed just beyond the elastic limit by an internal pressure of 315 psi applied with a duplex pump.

The restored pipe was drained and sealed, and the ditch was flooded to

float it out of its position. The combination of flooding and backfilling raised it high enough for several tractors to haul it out. It was then blocked up on sleepers, and one of the bulkheads was removed. The interior was then cleaned of loosened cement-mortar lining.

fillet weld on the outside. The 36-in. test pipe was pulled inside the larger pipe and was blocked in place with one end of the 36-in. pipe 4 ft from the manhole end of the 49-in. pipe (Fig. 4). Six-inch taps were welded to the bulkheads of the 36 and 49-in. steel pipes, and these two stubs were joined

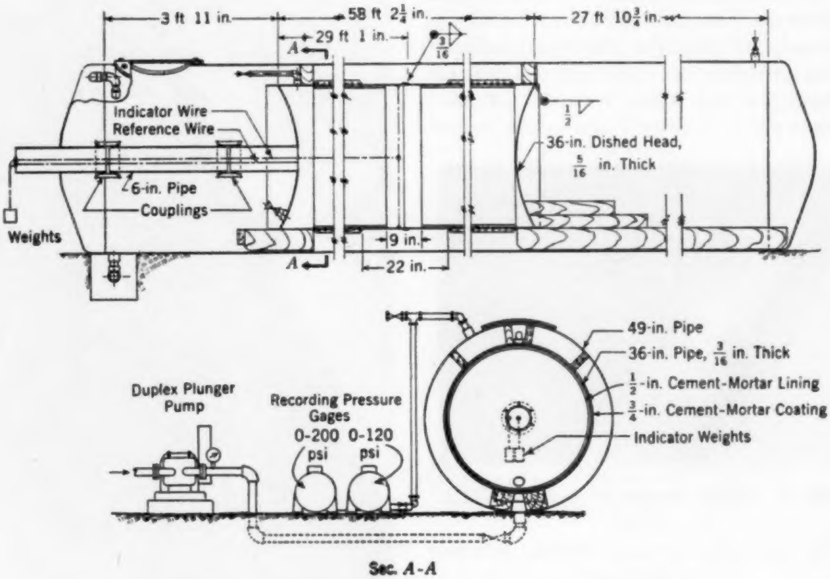

Fig. 4. Arrangement of 36-in. Pipe Inside 49-in. Pipe

The 36-in. pipe was blocked in place inside the 49-in. pipe.

Additional Test

Another assembly was constructed of two 30-ft lengths of 36-in. ID steel pipe with a wall thickness of $\frac{3}{16}$ in., a centrifugally spun cement-mortar lining $\frac{1}{2}$ in. thick, and a cement-mortar brush coat $\frac{3}{4}$ in. thick. The ends were enclosed by dished heads, concave sides out. The center circumferential joint was a bell-and-spigot joint, fillet welded inside and out. The $\frac{5}{16}$-in. thick dished heads were welded to the inner circumference of the pipe with a large

with 6-in. steel pipe and Dresser couplings so that the inside pipe could exhaust to atmosphere when it collapsed and any movement in collapsing would be restrained as little as possible by the outside pipe. Figure 5 shows the crude indicator which was made of small pigs of lead and strings attached to the inner pipe to show movement, if and when it collapsed. The instruments were equipped with 60-min chart drives and had different pressure ranges in order to record any extremes.

After the installation was completed the space inside the 49-in. diameter pipe was filled with water in order to impose a gradually increasing hydrostatic pressure on the outside of the 36-in. pipe. The 65-psi hydrant pressure was increased with a duplex pump until the 36-in. pipe finally gave way at an external pressure of 76 psi. In order to see what had happened to the 36-in. pipe, the apparatus was dismantled and the bulkheads were cut off the 49-in. pipe, which was also cut into its original three 30-ft sections. The smaller pipe was then dragged into the open by a tractor.

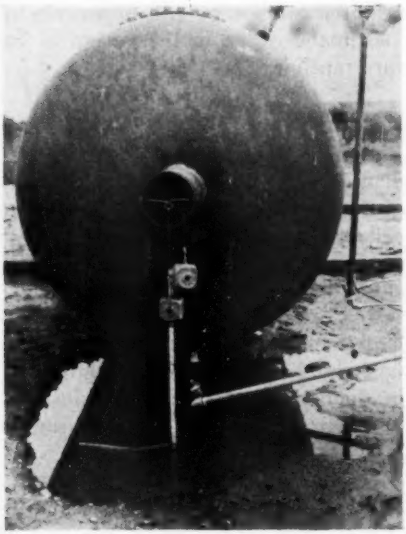

Fig. 5. Crude Indicator

Small pigs of lead were attached by strings to the inner pipe to show movement.

It could be seen that the pipe collapsed in the center, at the junction of the two 30-ft lengths, and tore transversely through the pipe metal and not at the circumferential weld (Fig. 6).

When the two lengths were welded together the joint was neither coated nor lined. Approximately 9 inches of bare metal was exposed on the inside and approximately 22 inches on the outside. It was thought that these short lengths of exposed metal could be neglected—that the lining and coating on the remainder of the pipe would spread their supporting qualities to the bare section—but this was only partially true. The calculated collapsing pressure for the 36-in. bare steel pipe as influenced by restraining bulkheads and according to the von Mises formula was 12.58 psi. The actual collapsing pressure of the specimen used was 76 psi, but the appearance and location of the damage indicated that if time had been taken to line and to coat the bare steel with cement mortar at the juncture of the two sections of 36-in. pipe, the pressure at which the pipe collapsed would have been higher. Figure 7 shows the damage to the 36-in. pipe. The 36-in. pipe was subjected to 155 psi of pressure, an amount that, although not high enough to stress the pipe to the elastic limit, was the highest

Fig. 6. Collapsed Pipe

Close-up of damage showing pipe collapsed in the center at junction of two 30-ft lengths.

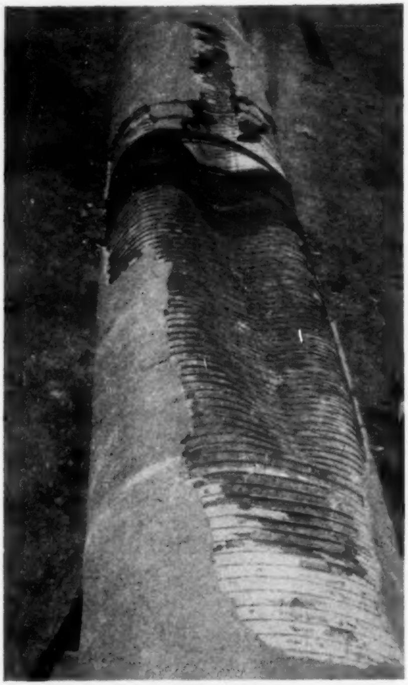

Fig. 7. Damage to 36-in. Pipe

The 36-in. pipe was subjected to 155 psi of pressure.

that could be used because the bulkheads had turned inside out, tearing the pipe wall at the weld, so that the pipe had begun to leak faster than it was practical to patch it.

Savings

The original design of the Sequoia Aqueduct Extension specified the installation of air and vacuum valves at an estimated cost of $50,000. As a result of the experiments, it was decided to reduce the number of air and vacuum valves just to those necessary to fill or empty the pipeline, the estimated cost being $20,000. The net cost of conducting the experiments, after credit for salvage, amounted to approximately $2,535. By spending $2,535 for these experiments, the district was able to make an estimated saving of $30,000 which equalled a net estimated saving of $27,465. In addition, the personnel acquired knowledge and experience of inestimable value in the design of future pipelines.

Conclusions

1. The experiments on the 49-in. diameter pipe indicate the dependability of the von Mises formula as applied to collapse from external pressure of large-diameter bare steel pipe with closed ends.

2. Customary thicknesses of portland cement mortar of $\frac{3}{4}$ in. for coatings and $\frac{1}{2}$ in. for lining strengthen 36-in. diameter bare steel pipe against collapse from external pressure by at least 600 per cent.

3. Vacuum valves can be largely omitted in the installation of large-diameter bare steel pipe if the pipe is lined and coated with a good portland cement mortar.

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Weather Control

Task Group Report

A report by Task Group E-2A—Weather Control, presented on May 7, 1952, at the Annual Conference, Kansas City, by E. H. Guyer, Chairman, Secy.-Supt. Escondido Mutual Water Co., Escondido, Calif. The other members of the task group are Paul D. Cook, R. A. Duff, Thomas J. Eaton, Herbert E. Hudson Jr., Elmo James, Percy A. Shaw, R. B. Simms, and Ross A. Thuma.

WEATHER control could be of value to every section of the U.S. Certain areas of this country are always in need of water while other parts are blessed with an abundance and, at times, still other areas are drenched with far more water than can be used or preserved. From the beginning of time, man has prayed to his gods and offered up sacrifices in the hope of bringing rain to make his crops abundant or of shifting the winds to preserve him from shipwreck. Man has always dreamed of ways to change the weather and has been attempting to accomplish that end.

In the parts of the U.S. where subtropical fruits are produced, the grove managers have spent thousands of dollars in heating their orchards to protect their fruit from damage. During World War II, in England, the need to bring planes in through the fog when returning from their bombing missions over Germany brought forth "Operation Fido," a method of dissipating fog to clear the air over the runways.

In 1916 the city of San Diego, Calif., contracted with a rainmaker to bring rain in sufficient quantities to fill the city's reservoirs. This rainmaker was so successful that floods followed and he had to leave town without collecting his fee because of threatened damage suits (1). All were aspects of weather control.

It was not until recent years that the scientist demonstrated in his laboratory that, by the application of certain methods to controlled conditions, he could stimulate precipitation of moisture from the air. In 1946 the General Electric Co., after numerous experiments, evolved a laboratory method for changing supercooled clouds to ice crystals. This company holds patents on its basic ideas but it has publicly declared that, until further notice, it does not intend to attempt to enforce any of them (2). This has thrown the field open to free experimentation. The General Electric Co. has continued its experiments and has gathered much information about precipitation mechanisms. This information has also been made public and is being applied in many parts of the U.S. to the cloud formations that nature furnishes. These applications are primarily for the beneficial increase of rainfall. In addition, the knowledge gained by the General Electric Co. is

being applied in an attempt to change the character of precipitation—to make the rains fall gently and to eliminate hailstorms that damage growing crops. In other areas, these methods are being applied to increase snow packs in the mountains so that more water will be available for the generation of electric power, irrigation, and consumption by the city dweller. This aspect of weather control is variously known as cloud seeding, artificial nucleation, rainmaking, and rain increasing.

Weather Control Programs

Modern rain increasing is based on the fundamental ice crystal precipitation theory of Bergeron and Findeisen which states: "For modern or heavy precipitation to fall, there must be sufficient ice crystals present in the supercooled clouds to initiate this process."

In 1946 Schaefer and Langmuir demonstrated the method of converting these water droplet clouds into ice particle clouds with extremely cold dry ice. Since then, other chemicals, such as silver iodide, cadmium iodide, and mercuric iodide, have been used.

The meteorologist, unable to perform magic, needs the help of nature to produce the desired precipitation phenomena. The necessary conditions include: [1] a cloud containing water droplets below freezing temperature; [2] a minimum cloud thickness of 3,000 to 5,000 ft; [3] vertical and horizontal air currents within the cloud to carry in water from the surrounding air.

Ice crystals within a cloud grow very rapidly by attracting to themselves the small water particles of that cloud. Obviously, if maximum precipitation is desired from a given storm condition, the correct amount of nucleating agent to allow the ice particle to grow indefinitely until it can no longer be supported by the vertical air currents must be used. At this point, the ice particle will fall to the ground at its maximum size. If the air is cold in the lower atmosphere, the particle falls to the ground as snow. If the particle strikes higher temperatures near the ground, the snow melts into rain.

Of the total land area in the U.S., approximately 40 per cent or 742,000,000 acres receive 20 in. or less of precipitation per year (3). In a part of these arid or semiarid regions this precipitation may occur throughout the year. In other parts it falls only in the winter season and, depending on the latitude or elevation, may be in the form of rain or snow. If this rain or snow came at the exact time that it could be put to use and if it always came in the proper quantities, perhaps there would be no need to attempt to change or add to nature's way of delivering moisture to the earth. Unfortunately, however, this ideal distribution does not occur.

Most of the 742,000,000 acres that receive 20 in. or less of precipitation lie west of the 100th Meridian, and it is in this western area that almost all of the weather-changing experiments have taken place. Eleven states—Washington, Oregon, Idaho, Montana, Wyoming, New Mexico, Arizona, Colorado, Utah, Nevada, and California—are wholly within this area, and six states—North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas—are partially within it. Ten of the eleven states which lie west of the 100th Meridian supported rain-increasing projects in 1951. All of the six states, parts of which lie west of the 100th Meridian, were the sites of

experimental projects. Of the remaining 31 states only three—Ohio, New York, and Missouri—have been the location of rain-increasing projects. In Ohio, the Weather Bureau conducted experiments, and the Signal Corps, U.S. Army, and Office of Naval Research, in consultation with the General Electric Co., began in 1947 a cooperative research investigation in cloud physics known as "Project Cirrus." New York City, in 1950, seeded clouds to increase its water supply and a private company in Missouri conducted one experiment.

In the states west of the 100th Meridian, the majority of the rain-increasing programs were conducted primarily for the benefit of agriculture. The activities located east of the Rockies and west of the 100th Meridian are described in the "Report on the Meeting of the Great Plains Council" (4). There has been no general report on activities west of the Rocky Mountains but most of the work conducted in that area has been for the benefit of agriculture.

There has been grave concern about the water supply of some of the municipalities in Southern California. San Diego has been particularly interested in increasing its supply of water and in the winter of 1950–51 conducted a rain-increasing project. In the winter of 1951–52 San Diego joined all the water distributing agencies in San Diego County to establish and conduct a rain-increasing project. The parts of San Bernardino, Riverside, and Orange Counties that lie along the Santa Ana River combined to conduct a program. The Santa Barbara area conducted a program and even as far north as Santa Clara County near San Francisco a program was initiated. The California programs were established for the benefit of both agriculture and the municipalities. The projects in western Washington, Oregon, Montana, Arizona, Utah, and Nevada were financed and operated by and for the benefit of agriculture.

Public Opinion

The attitude of people, both in and out of government, toward the experiments in rainmaking varies from enthusiastic support to opposition and ridicule. A. M. Eberle, Dean of Agriculture at South Dakota State College, Brookings, S.D., said in the "Resources Bulletin" (5): "We may smile and think it quite visionary, but the next few years will see great strides made in this direction. . . . Just think what a program of this kind would mean to South Dakota, if it becomes a reality."

Ross Thuma, St. Paul, Minn., in a letter to the chairman, said: "It seems to me that this is a subject that should be given major consideration by the AWWA. The cost seems to be rather nominal for the rainmaking and the possibilities so far-reaching. Viewed from the scientific standpoint of agriculture, food supply and water supply, it seems to have endless possibilities."

Vincent Schaefer, the General Electric scientist has said (6): "Cloud-seeding is a complicated science, of which we have so far discovered only an inkling of a few general principles. It was a long way from the discovery of electromagnetic waves to their application in the modern radio. Scientists have known for years that they could produce better crops by adding plant nutrients to the soil, but they are still learning how to do it. We have discovered that weather can be artificially

TABLE 1

*State and National Weather Control Legislation**

State	Legislation	Comments
New Hampshire	Introduced in legislature.	Failed to pass Senate
Massachusetts	Weather Amendment Board created and approved 7/17/51. Gives full control to any weather amendment.	Board not organized nor any business before it
Connecticut	Introduced in 1951.	Killed in Senate; not taken seriously
New Mexico	Senate Bill No. 219. Declares study and analysis and attempted rain increase to be for scientific purpose.	
Wisconsin	Proposed.	
Wyoming	Chap. 131 (Session Laws of Wyoming, 1951). Claims sovereignty to its atmospheric moisture. Provides for evaluation of data and creates Weather Modification Board.	
Colorado	House Bill 251 (Session Laws, 1951), approved 3/28/51. Claims sovereignty to its atmospheric moisture. Provides for evaluation of data and creates Weather Control Commission.	
California	An act to provide for the regulation and licensing of artificial nucleation operations. Chap. 1677, Statutes 1951. An act authorizing State Water Resources Board to engage in research on production and control of rainfall by artificial means and appropriating $50,000. Chapter 1596, Statutes 1951. An act adding to powers of Riverside County Flood Control & Water Conservation Dist. authorizing it to carry on a program of artificial nucleation and providing for levy of taxes to finance such activity. Chapter 1374, Statutes 1951.	

* No legislation has been passed in the remaining 37 states not listed.

modified in certain ways. I am sure that as we learn how to do it better, cloud-seeding will become a more and more important aid to agriculture and industry."

James B. Collinson, a banker who lives in Devils Lake, N.D., expressed his views: "I am a local banker who was drafted to serve as a secretary-treasurer of the Ramsey County Rain Increasing Assn. As I learned about the success this company (Water Resources Development Corp.) has had elsewhere, I became enthusiastic about the possibilities for this area. In spite of an unimpressive first year, the potential benefits are so tremendous in relation to the cost, I am hoping that we can give it a thorough trial here."

Thomas J. Eaton of the Public Service Co. of New Mexico, Santa Fe Div., stated: "The state and local authorities have maintained a neutral attitude hereabouts but certain groups of people have found themselves in the mid-

TABLE 1—*Continued*

State	Legislation	Comments
Utah	1951 legislature passed law permitting counties to levy up to 1 mill tax for investigating rainmaking.	
Arizona	License to operate and report on subsequent rainmaking activity required. License also required to make and sell equipment. Exception: Farmers. Senate Bill 46, passed Mar. 29, 1951.	
Oklahoma	None	Legislation under study

Senate Bills introduced into 82nd Congress, First Session. Joint hearings held before subcommittees of the Committees on Interior and Insular Affairs, Interstate and Foreign Commerce, Agriculture, and Forestry, U. S. Senate, March 14–19, and April 5, 1951 (2).

S. 5: A bill to provide for research into and demonstration of practical means for the economical production, from sea or other saline waters, or from the atmosphere (including cloud formations), of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, and for other purposes.

S. 222: A bill to provide for the development and regulation of methods of weather modification and control.

S. 798: A bill to authorize the Secretary of Agriculture to conduct research and experiments with respect to methods of controlling and producing precipitation in moisture-deficient areas.

Senate Bill introduced by Senator Case of South Dakota on October 8, 1951, and subsequently referred to the Committee on Interstate and Foreign Commerce.

S. 2225: A bill to create a committee to study and evaluate public and private experiments in weather modification.

dle of highly controversial discussions. It would appear, of course, that those who make the highest claims for the effectiveness of rainmaking suddenly find themselves involved in damage suits. On the other hand, those opposed to it have loudly proclaimed that the money spent on contracts has been entirely wasted and that the rain would have been received anyhow."

In the report on "Proceedings of the Great Plains Council" (4), James Wilson, of Fort Collins, Colo., Secretary of the National Weather Improvement Assn., maintained: "This whole thing is so new that it is still only an experiment, though an experiment on a vast scale. None of us know how it is going to work out. We know the scientific principle works in the laboratory, but there is a lot to learn before we can definitely say that the laboratory results can be duplicated consistently on a large scale over and over again in the natural atmosphere."

P. A. Shaw of the Manchester, N.H., Water Works, in a letter to the chairman quoted William S. Wise, Chief Engr., Connecticut State Water Com.: "A bill was introduced in our last legislature (1951) to set up some sort of control over rainmaking and weather control work. The control under this bill would have been placed under the State Water Com. The legislative committee which heard the bill viewed it as sort of a joke and consequently no action was taken on it."

F. W. Reichelderfer, Chief, U.S. Weather Bureau, Washington, D.C., stated in a letter to the editor of the Washington *Post* (7): "Most meteorologists recognize that in some cases rainmaking experiments have been successful in increasing the amount of rainfall, but there have been many other instances where rainfall which was reported to have been caused by artificial means has unquestionably been solely the result of natural causes. The Weather Bureau seeks to work closely with all experimenters who are trying to obtain the facts and distinguish precipitation which would fall naturally without the aid of rainmakers from that which results from artificial efforts."

From these quotations it is evident that there is a great deal of local interest in weather modification. In every section where projects have been conducted, local interest has increased, as evidenced by continued financial support of the various projects.

Legislation

Arizona, California, Colorado, Massachusetts, and Wyoming have adopted legislation designed to claim atmosphere-borne water for their citizens and to control and evaluate weather control programs. Legislation introduced in Connecticut and Vermont failed to pass.

In March 1951, joint hearings were held before subcommittees of the Committees on Interior and Insular Affairs, Interstate and Foreign Commerce, Agriculture, and Forestry in the U.S. Senate to discuss bills regarding research, development, and regulation of methods of weather modification and control.

On October 8, 1951, Senator Case of South Dakota introduced a bill (S. 2225) into the 82nd Congress "to create a committee to study and evaluate public and private experiments in weather modification." This bill has been read twice and referred to the Committee on Interstate and Foreign Commerce (Table 1).

Results

As only approximately six years have elapsed since Langmuir and Schaefer announced their discoveries, there has not been sufficient time to obtain complete information on the results. It is generally believed that it will take a number of years of continued work to gather sufficient data to prove or disprove the value of the programs. Results have indicated the advisability of continuing experimental work but there is much to learn before it can be ascertained whether laboratory results can be consistently duplicated in the atmosphere on a large scale.

Hydrology is the applied science treating of the waters of the earth—their occurrences, distribution, and circulation through the unending hydrologic cycle of precipitation, consequent runoff, infiltration, and storage, eventual evaporation, and reprecipitation. Considering this definition of hydrology and, at the same time, the possibilities of increasing precipitation by some artificial means, it is interesting to contemplate the possibility of increasing the circulation of water through the unending hydrologic cycle.

If it is remembered that the term water works refers to the acquisition and distribution of water for agriculture, as well as for domestic and other municipal uses, it becomes clear that

acceleration of the unending hydrologic cycle by artificial methods could materially affect the pattern of availability of water for water works.

Summary

Since the discovery in 1946 of a laboratory method for changing supercooled clouds to ice crystals, rain-increasing experimental work has been conducted in 20 of the 48 states by private enterprise. The U.S. Weather Bureau has indicated interest in these programs and has conducted some experimental work of its own. Most of the cloud seeding work has been conducted in the arid or semiarid part of the country—that is, west of the 100th Meridian. It is, therefore, safe to assume that the necessity for a greater water supply has determined the location of these attempts. Legislation has been adopted by five states and has been considered by two others. Congress has recognized the potentialities and is considering Senate Bill 2225. Results to date are promising, and hold out particular hope for increasing the availability of water for water works.

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3. The Colorado River. Dept. of Interior, Bureau of Reclamation Pub. (March 1946).
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5. Eberle, A. M. South Dakota Natural Resources Commission Bulletin. File Abstract, **IV**:1-A (Jan. 2, 1951).
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7. Reichelderfer, F. W. The Washington *Post*, Letters to the Editor (Dec. 19, 1951).

New AWWA Division

A new AWWA division—the Transmission and Distribution Division—was formed on May 6, in the course of the Kansas City Conference. The division is the Association's fourth, and rounds out the areas of special interest covered by the first three: the Water Works Management, the Water Resources, and the Water Purification Divisions. The scope of the Transmission and Distribution Division will include design, construction, operation and maintenance activities in the fields of power, pumping, transmission, distribution, customer services, and metering of public water supply. The officers elected to head the new division during the coming year are listed on p. iv of this issue.

Fundamental Studies of Taste and Odor in Water Supplies

By F. M. Middleton, Harry Braus, and C. C. Ruchhoft

A paper presented on Oct. 4, 1951, at the joint meeting of the West Virginia Section and the West Virginia Sewage & Industrial Wastes Assn., Charleston, by F. M. Middleton, Scientist, Harry Braus, Chemist, and C. C. Ruchhoft, San. Engr.-Director, all of the Environmental Health Center, U.S. Public Health Service, Cincinnati, Ohio.

OBJECTIONABLE tastes and odors in drinking water are of considerable concern to consumers, water works operators, and public health officials. The control of these taste and odors is a major problem in the field of water purification. It is believed that most tastes and odors in water supplies are due to the presence of organic chemicals. The organic impurities may arise from industrial wastes, domestic sewage, natural run-off, and the growth and decay of aquatic plants and animals.

The concentration of these taste- and odor-producing substances in water is usually so small that they cannot be detected nor measured by ordinary analytical techniques. For this reason, little has been learned concerning the chemical composition of these materials, with the exception of the phenolic type compounds, which have been studied extensively to determine their relation to taste and odor in water supplies. The Public Health Service Drinking Water Standards (1) state that no more than 1.0 part per billion (ppb) of phenol shall be present in finished water. Studies of phenolics have been possible because satisfactory procedures for the measurement of small quantities of phenol in water and wastes have been developed (2, 3). Other organic chemicals may be as important or more important than phenol in causing objectionable conditions in water.

Knowledge of the chemical identity and the quantities of specific organic chemicals present in water would provide much needed information on taste- and odor-producing chemicals. Methods for the control of tastes and odors in water have been developed by trial and error. More effective and more economical methods for their control could probably be devised if the exact nature of the causative substances could be demonstrated.

As little is known of the persistence of polluting organic compounds in flowing streams or other surface waters, a technique for tracing these materials from a water supply to the source would materially aid in these studies. In addition, it is important to know whether organic chemicals occurring in drinking water have toxic or other physiological effects on humans or animals.

Concentration Technique

A method called the carbon filter technique has been developed in the authors' laboratories for the concen-

TABLE 1

*Total Organic Extract Recovered From Raw Water Using Granular Cliffchar Carbon**

Location of Water Plant	Source of Water	Filter in Service		Quantity of Water Tested *gal*	Organic Material Extracted	
		From	To		*g*	*ppb*
Wheeling, W.Va.	Ohio R.	10/27/49	9/ 5/50	30,200	2.49	21
Cincinnati, Ohio	Ohio R.	11/29/49	1/18/50	5,300	1.80	89.5
Louisville, Ky.	Ohio R.	12/30/49	5/ 2/50	68,570	2.18	8.5
Decatur, Ala.	Tennessee R.	7/ 7/49	10/14/49	29,150	0.83	7.5
Oklahoma City, Okla.	North Canadian R.	2/14/51	2/28/51	10,000	0.98	26
Nitro, W.Va.†	Big Kanawha R.	8/21/51	9/ 6/51	5,350	20.02	960

* Raw water was sampled at every plant except the Wheeling plant at which filtered raw water was sampled.
† C-190 carbon used in filter.

tration and study of the small quantities of organic chemicals which are present in surface waters. Concentration is effected by passing 5,000 to 10,000 gal of water through a small activated carbon filter at a rate of ¼ to ½ gpm. Field filters consist of a length of 4-in. iron pipe with suitable screens for holding the carbon in place. When turbid waters are being studied, the carbon filter is preceded by a similar pipe which contains sand and gravel arranged to permit backwashing. Figure 1 shows the filter arrangement used in field studies. When sufficient sample has been collected, the carbon is removed from the filter and air dried, and the organic materials are desorbed from the carbon with chloroform or ether in a Soxhlet type extractor. The solvent is distilled from the extract and the remaining moisture is removed. The organic residue is then ready for further examination. Complete details of the methods and equipment are given by Braus et al (4). The present paper gives recent findings and applications of the technique to water quality studies.

Study Areas

Waters known to be polluted with and known to be free from industrial contamination were included in the investigation. The carbon filter technique has been used to investigate a number of water supplies having the Ohio River as a source, and one supply having the Big Kanawha River as a source. Impounded supplies such as those in the Tennessee Valley have been examined for taste- and odor-producing compounds.

Organic Extracts

Two types of active carbon were used in these studies—Cliffchar * granular carbon for most of the field sam-

* A product of Cliffs Dow Chemical Co., Marquette, Mich.

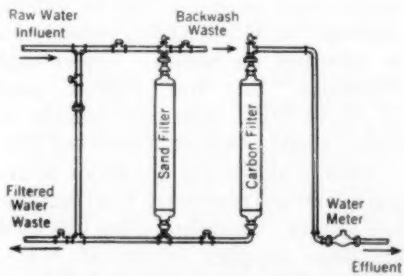

Fig. 1. Sand and Carbon Filter Installation

This installation is used in field studies for sampling turbid water for trace quantities of organic chemicals.

TABLE 2

*Organic Extract Recovered From Cincinnati Tap Water**

Series Number	Filter in Service		Quantity of Water Tested *gal*	pH of Water	Organic Material Extracted	
	From	To			*g*	*ppb*
1	8/10/50	8/29/50	5,400	8.5±0.3†	1.46	71
1a	8/10/50	8/29/50	5,400	3.0 – 4.0	1.39	68
2	10/26/50	12/ 7/50	12,096	8.5±0.3	3.25	71
2a	10/26/50	12/ 7/50	12,096	8.5±0.3	1.26	28
3	12/ 7/50	12/26/50	7,000	8.5±0.3	2.70	106
3a	12/ 7/50	12/26/50	7,000	3.0 – 4.0	3.0	113
4	12/27/50	1/29/51	11,640	8.5±0.3	4.56	103
4a	12/27/50	1/29/51	11,640	3.0 – 4.0	10.88	247
5	1/29/51	2/15/51	5,160	8.5±0.3	1.98	101
5a	1/29/51	2/15/51	5,160	3.0 – 4.0	1.42	72

* Two carbon filters used in series under alkaline and acid conditions.
† Usual range of pH of Cincinnati tap water.

ples and Nuchar † C-190 unground carbon for laboratory and some field studies. The C-190 carbon usually adsorbs four or five times as much material from the water as does the Cliffchar granular carbon. Until recently, difficult flow problems have prohibited the use of the C-190 carbon in field studies.

The quantities of extract recovered do not necessarily represent the total amount of organic material present in the water. Carbon tends to adsorb the least polar and least soluble organic compounds. In an alkaline water, a soluble ionic substance such as sodium caproate ($C_5H_{11}COONa$) would not be adsorbed on carbon. Under acid conditions, the free caproic acid ($C_5H_{11}COOH$), sparingly soluble in water, would be strongly adsorbed (5).

Table 1 shows the quantities of organic extract recovered from various raw waters. Granular carbon was used on these supplies except at Nitro, W.Va., where approximately 1,000 ppb of material was recovered using C-190 carbon in the filter.

Some of the organic chemicals in raw water survive water treatment processes, including free residual chlorination. This survival is shown by the recoveries listed in Table 2 of several extract samples from Cincinnati finished water which were passed through filters of C-190 carbon. This water was free-residual chlorinated, coagulated, and filtered in the usual manner. Table 2 also indicates the effect of different pH values on the recovery of extracts. Water that was passed through one carbon filter under alkaline (pH 8.5) conditions was acidified and passed through a second carbon filter. The recovery of extract on the second filter was usually equal to or greater than the quantity of extract recovered from the first filter.

When two filters are placed in series without changing the pH of the water (Series 2a, Table 2), the second filter may adsorb approximately 40 per cent as much material as is adsorbed on the first filter in the series. Figure 2 shows an arrangement that may be used in the laboratory to feed acid or

† A product of Industrial Chemical Sales Div., West Virginia Pulp & Paper Co., New York.

base to the water ahead of the filter units. Adsorption on carbon under highly alkaline conditions has not been studied.

The effectiveness of activated carbon in the removal of organic chemicals from water was carefully tested on a plant scale at the Cincinnati Water recovered. On the basis of the extract recovered, the 10-ppm dosage of carbon removed 63 per cent of the organic materials from the sand filter influent. Approximately 100 ppb of organic material was recovered from the Cincinnati water which received no carbon treatment.

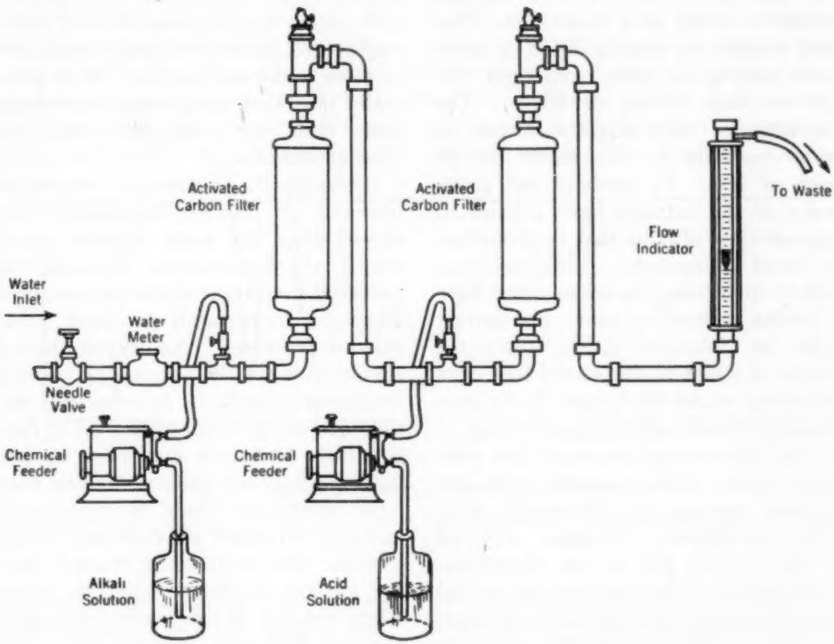

Fig. 2. Activated Carbon Filter Assembly

This assembly is used in the laboratory to extract organic chemicals from water.

Filtration Plant in cooperation with the Industrial Chemical Sales Div., West Virginia Pulp & Paper Co. Two regular rapid sand filters were used in the experiment. The influent to one filter was dosed with 10 ppm of Aqua Nuchar A active carbon by means of a chemical feeder. The second sand filter received no carbon. Equal quantities of the two sand filter effluents were passed through experimental carbon filters and the organic extract was

At Nitro, W.Va., carbon filters were placed on the raw and finished water and were operated for the same period of time at the same rate of flow. The extract recovered from the raw and finished water amounted to 1,010 and 184 ppb, respectively. Water treatment at Nitro on the basis of this test removed 82 per cent of the organic chemicals from the raw water. During this period the Nitro water underwent high-pressure aeration and was treated

with large quantities of activated carbon for taste and odor control. The water was coagulated, filtered, and chlorinated in the usual manner.

The chloroform or ether used in the extraction usually turns yellow or brown after contact with the carbon for several cycles in the Soxhlet extractor. The solvent is distilled and the organic residue is dried in a desiccator. The final extract is a viscous liquid or semisolid ranging in color from light yellow to dark brown or black. The extracts are only slightly soluble in water—usually to the extent of 10 ppm or less. In concentrated form, many of the extracts have a paint or varnish type of odor that is obnoxious to most observers. Samples from widely distributed locations often have a similar underlying odor. An extract from the Columbus, Ohio, water, the source of which is considered free from industrial waste discharges, had a particularly musty, earthy type of odor.

The extracts are separated into phenolic, basic, acidic, neutral, and amphoteric groups by differential solubility procedures. Samples collected at the normal pH of the Cincinnati water supply indicated that the neutral group is usually present in the greatest quantity. The odor of this group is offensive and is similar to the odor of the raw extract. The phenols separated from Cincinnati tap water appear to be mixed in character and have a cresolic or somewhat chlorophenolic odor. The organic acids which were separated have aromatic odors and resemble, in general, the odors associated with aliphatic acids in the C_8 to C_{10} range. The basic compounds are largely organic amines. The odor is tobaccolike, similar to pyridine. Very small quantities of the basic compounds have been separated. Under acid conditions the largest fraction of material recovered from the carbon filter appears to be composed of organic acids. These materials have not yet been separated or identified. Other chemicals identified in the extracts by spot tests include pyrrole type compounds, pyridine, hydrocarbons, and terpene type compounds. The amphoteric group has not been studied thoroughly as it is not considered significant in taste and odor studies. It is generally true that compounds containing more than one polar group are not odor producers.

Although the precision of the measurement of organic compounds removed from the water may be questioned, the experiments illustrate the potential usefulness of the carbon filter technique in research on water purification processes. Additional studies should indicate the efficacy of various treatment procedures in removing minute quantities of impurities. The carbon filter technique may have certain inadequacies, but the authors feel that most substances likely to cause taste and odor in water are collected on the carbon. The materials extracted from the carbon produced odor in water when present in very low concentrations. Activated carbon has been widely used to reduce effectively, or to eliminate, tastes and odors in water supplies and appears to be the best material for use as an absorbent in making laboratory studies of taste and odor. Highly volatile materials may be lost using the carbon filter technique, but it is not likely that such materials would persist long in the stream, nor is it believed that volatile materials are important causes of taste and odor in water.

Work with the small quantities of materials available requires micro-,

chromatographic, counter current extraction, and other special analytical techniques. Investigations using these methods are being conducted, but much work remains on the identification of these organic materials.

Infrared Analysis

The infrared recording spectrophotometer appears to offer one of the most promising methods for the analysis of minute quantities of material. An infrared spectrogram of a compound will indicate the presence or absence of certain organic groupings. This information saves the analyst much exploratory work with a consequent saving of time and sample. The infrared examinations were made on a Baird Double Beam Recording Spectrophotometer using extracts from various waters. Infrared methods do not give the final answer in determining the chemical constitution of mixed organic extracts which are recovered from carbon in water purification studies but they do offer many possibilities.

Figure 3 shows the infrared spectrum of an extract obtained from the raw Kanawha River water at Nitro, W.Va. This extract contains a mixture of organic chemicals not easily separated into pure constituents. Absorptions at 6.26, 6.7, 6.83, and 7.25μ, suggestions of absorption at 9.3 and 9.7μ, and absorptions at 13.2 and 14.4μ indicate the possibility of some 1,2 disubstituted and monosubstituted hydrocarbons. Compounds such as the keryl benzenes, intermediates in the manufacture of wetting agents, exhibit infrared spectra similar to that of the Nitro extract. Esters of aromatic carboxylic acids also absorb at 8.9μ and exhibit the strong carbonyl absorption indicated in the 5.9-μ region.

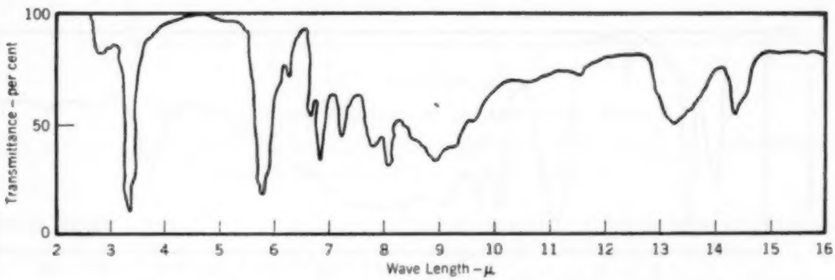

Fig. 3. Infrared Spectrum of Organic Extract

The extract was obtained by the carbon filter technique from raw Kanawha River water at Nitro, W.Va.

An extract from the Huntington, W.Va., water supply was examined for infrared absorption characteristics (Fig. 4). Huntington obtains water from the Ohio River but the supply may also be influenced by the water from the Kanawha, the stream that serves Nitro, W.Va. Huntington is approximately 80 mi, by river, from Nitro. The strong absorption band in Fig. 4 at 2.9μ indicates the presence of NH or OH groups. The band at 4.5μ may be due to a triple bond like that of the nitriles (—C≡N). The broad absorption band between 5.6 and 6.0μ indicates carbonyls (C=O), possibly

several kinds. The C—H absorptions at 3.4, 6.83, and 7.25μ are common to most organic chemicals but may yield important information.

Interpretation of the infrared spectra of the extracts from Nitro and Huntington provides the analyst with clues for further chemical testing. The materials can be separated into acids, bases, and neutral compounds. Tests will show whether the carbonyl is due to acids, aldehydes, ketones, or other sources. Tests for amines may establish whether the bands at 2.9μ are due to NH or OH. Phenols may be separated from the mixture if present.

materials would come from the filter itself. A recovery of 3 g from 4,300 gal of water was obtained and an infrared spectrogram of the material using 2 or 3 drops of sample indicated hydrocarbons. The identification of hydrocarbons suggested the possibility of lubricating oil leaking from the pump bearings. An infrared spectrogram of the lubricating oil authenticated the supposition. The well pump was worn and large amounts of oil were used in lubricating the bearings.

The carbon filter technique has been used in studying the waste effluent from a gravity oil separator at an oil

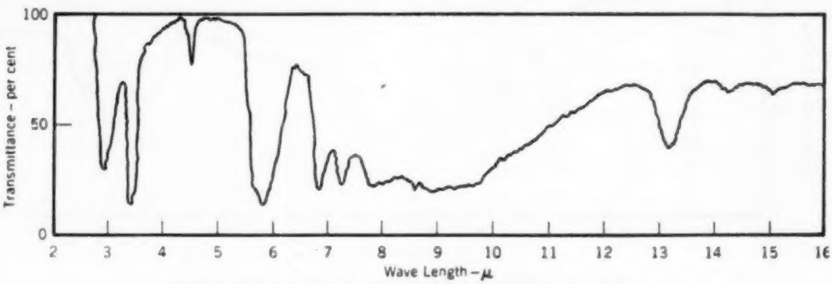

Fig. 4. Infrared Spectrum of Organic Extract

The extract was obtained by the carbon filter technique from Huntington, W.Va., finished water.

By such means it should be possible to establish whether the Huntington water actually contains chemicals similar to those found at Nitro. The fate of certain organic chemicals in a flowing stream may be studied and their role in causing tastes and odors established.

An interesting application of infrared techniques occurred in the examination of an extract from a deep well. An experimental carbon filter was placed on the discharge of the well. The authors anticipated that little or nothing would be recovered from the well water and that any recovery of

refinery. The extracts from the carbon filters were separated into acidic, basic, neutral, and phenolic groups. The neutral group comprised approximately 85 per cent, phenolics 4 per cent, and acids and bases less than 1 per cent of the total extract. Approximately 10 per cent of the material was either insoluble in ether or was lost through manipulation. The neutral fraction seemed to be chiefly responsible for the production of odor in this waste. Figure 5 shows the infrared spectrum of this fraction of the extract. The strong C—H absorptions at 3.4, 6.83, and 7.24μ indicate a mixture of aliphatic,

aromatic, and alkylated aromatic hydrocarbons. Chemical tests confirm this interpretation. The phenols in the refinery waste may also contribute to taste and odor but appear to be of minor importance as the odor of the extract from the waste effluent is hydrocarbonlike and not phenolic.

believed to be important contributors to taste and odor in water.

Further taste and odor tests will be made on organic groups and individual constituents as they are separated. This type of study appears to have useful application in determining the true causes of taste and odor emanating

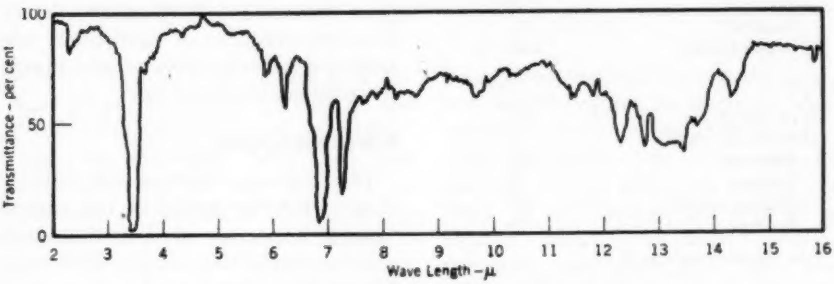

Fig. 5. Infrared Spectrum of Neutral Group Extract

The extract was obtained by the carbon filter technique from the waste effluent of a gravity oil separator at an oil refinery.

Odor Tests

Weighed portions of the various extracts were diluted with odor-free water and the minimum concentration which could be detected by the odor test was determined. The threshold odor concentrations that were determined for some of these extracts are given in Table 3.

Table 4 shows the concentrations of raw extracts and organic groups separated from the raw extracts which could be detected by odor. The neutral compounds were present in larger quantities than any of the other organic groups separated. Also, the odor of this fraction is offensive. The amines have disagreeable odors but very small recoveries have been obtained. The role of organic acids, which are present in the extracts to varying degrees, is being studied, but these acids are not

from wastes. The technique offers a means for following the course of wastes in water following discharge and for the study of the products of natural purification of such wastes. The authors hope that a large series of such tests will reveal the types of material responsible for taste and odor. After these types of materials are iden-

TABLE 3

Lowest Concentration of Organic Extract Detectable by Water Dilution Method of Odor Testing

Source of Water*	Lowest Concentration of Extract Detected by Odor Test *ppb*
Huntington, W.Va.	13
Wheeling, W. Va.	25
Nitro, W.Va.	5
Louisville, Ky.	13
Columbus, Ohio	3
Decatur, Ala.	18

* All samples were sand filtered before they passed the carbon filters.

TABLE 4

Lowest Concentration of Organic Extract and Organic Groups Detectable by Water Dilution Method of Odor Testing

Source and Types of Organic Material	Lowest Concentration of Extract Detected by Odor Test* *ppb*
City A	
Raw Extract	25
Organic Groups	
Phenolic	50
Neutral	11
Organic acids	160
City B	
Raw Extract	10
Organic Groups	
Phenolic	25
Neutral	5
Organic acids	10
Amines	6

* All odor tests made at 30 C.

tified, intensive studies can be made of methods for reducing or eliminating them from wastes or water.

Summary

1. The carbon filter technique has been developed for the concentration and estimation of the small quantities of organic chemicals in water that may be responsible for tastes and odors.

2. Organic materials were recovered from various waters and were studied by group separation, spot tests, and infrared analysis.

3. The carbon filter technique is a useful method for tracing the course of an industrial waste in a body of water and for studying the effects of water treatment methods on the removal of organic chemicals from water. On a plant scale test at Cincinnati, 10 ppm of activated carbon removed 63 per cent of the organic chemicals which were present in the filtered water. At Nitro, W. Va., water treatment processes including large dosages of activated carbon removed 82 per cent of the organic chemicals from the raw water.

4. Compounds of a neutral character appear to be chiefly responsible for taste and odor in water. The organic materials isolated caused detectable taste and odor in water under laboratory conditions when present in concentrations as low as 5 ppb.

Acknowledgment

The authors wish to thank Graham Walton for the design of the various filtering apparatus used in this study and for conducting certain field tests. The kind cooperation of a large number of water works operators and officials in making these studies is also gratefully acknowledged.

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Budget Control

By Lauren W. Grayson

A paper presented on Oct. 25, 1951, at the California Section Meeting, San Francisco, by Lauren W. Grayson, Chief Engr. and General Mgr., Public Service Dept., Glendale, Calif.

ON April 2, 1951, a draft of the proposed budget request of the Public Service Dept. of Glendale, Calif., for the fiscal year 1951 was transmitted to the city manager of Glendale. The Public Service Dept. operates both the water division and the electric division. Thus, the budget request, an amount of $6,461,000, included both operations. On April 10, 1951, the electorate of Glendale denied the city council authority to issue general obligation bonds to the extent of $2,800,000 for the construction of a third unit to the city's steam generating plant. The budget request was predicated on the approval by the electorate of the $2,800,000 bond issue. The impossible—financing a minimum budget request operation of nearly $6,500,000 when more than one-third short of funds—has been accomplished in almost every respect.

Financial Set-up

A review of the financing arrangements of the department revealed that what appeared to be an unusual and unnecessary procedure was being followed. No contracts were entered into by the city unless funds in the department were available either in cash or in securities to satisfy the potential payment of the contract. It was recognized that the size of the operation would require contracts on which payments would be made or would become due months and even years after the date of the execution of the contract. As a result of this type of operation, moneys to satisfy contract payments may necessarily have been budgeted not once but in several years—for example, early in 1948 the city purchased a turbogenerator unit, and moneys for the purchase were budgeted in the fiscal year 1947–48. Delivery of the unit will be made early in 1952. Moneys for this purchase were budgeted five consecutive years and the funds of the department were tied up because of the encumbrances placed on funds as a result of this operating procedure, in addition to the apparent effect on the accumulated budget requests. A summary of the budget request for the five years shows five times the amount of funds requested as will be the ultimate expenditure.

For some time rates have been given considerable study, and a review of these studies was sufficient to warrant a recommendation to the council for an overall increase of 30 per cent. The recommendation was approved and the new rate, adopted by ordinance, became effective June 1, 1951. A further review of the rate structures

resulted in an increase of approximately 10 per cent in the electric rates to domestic and commercial consumers. The increase became effective August 1, 1951. The only material adjustment in the proposed program for which the budget was initially submitted was a delay in the construction of the proposed 2-mil gal concrete reservoir structure. The budget request was revised to the reduced figure of $5,453,000 and was approved by the council at approximately $14,000 less than the request.

Control

Budget control may be considered the control or regulation by a planned procedure of the estimated income and expenses of an operation for a certain period of time. This definition does not mean control by budget alone or a control of budget alone. Control should be used to the same degree to regulate and budget the income produced by rates charged for the services rendered as well as the expenditure of funds for the operation, maintenance, and expansion of the system.

Most budget operations cover a period of 1 yr although most planning is for periods of much greater length—5, 10, 20 yr and even longer. Therefore, for budget purposes and consistent with fiscal year operation, only a small segment of the more important period of a financing program will be considered.

Long-Range Planning

The budget of a given period may be considered the result of past experience combined with a segment of anticipated future developments. Past experience, when evaluated in current levels, provides a means of rating the general operating and maintenance costs of the utility and offers a foundation of unit cost experience that is valuable in determining the probable cost of planned development during the budget period. Future planning will give the basic requirements needed to continue service to customers in varying types of units, whether they be storage facilities, transmission lines, distribution system improvements, or sources of supply.

In general, a much sounder operation can be had if long-range planning is used to provide for a more uniform spread of capital expenditure requirements over a period of years. The units of the capital expenditures should be correlated with the operation and maintenance costs to establish an income requirement which would, in general, be subject to change primarily by the general economy at a national level.

Financing Utility Development

In the application of long-range planning, or, more specifically, planning for utility development, certain types of plants will require a considerable amount of capital for a single, or major item. Such projects are usually financed by bonded indebtedness or a "pay-as-you-go" method.

Bonded indebtedness is created on the basis of either revenue bonds or general obligation bonds, depending to some extent on the corporate structure of the serving agency. In general, the total financial requirement is determined prior to the approval of the bonding procedure and the bonds are issued and subsequently sold as needed to carry on the development. The capital expenditure program as entered into a period budget would reflect the estimates of that part of the

construction program occurring during the budget period, and would fluctuate in accordance with the construction program. The bonded indebtedness method of financing will introduce, as a revenue requirement, the need of funds for principal and interest payments during the period of retirement.

In contrast, the "pay-as-you-go" method requires that consideration be given to revenues in advance of the project construction period so that the needed funds will accumulate. This accumulation period may require several years for a single project or perhaps only a single year. The same variance in capital expenditure requirements in budget requests exists in the pay-as-you-go method as in the bonded indebtedness operation. The primary difference between the two methods is that of producing funds by revenue in advance of construction as compared to funds produced subsequent to construction.

Budget Equation

The major constituents of a time-period budget may be placed in their proper relation, one to another, to establish an equation. Operation and maintenance cost combined with funds for capital expenditures, will be on one side of the equation, with estimated revenues, plus or minus additions from, or contributions to, surplus funds on the other. By means of this equation, a budget for control purposes can be established.

The level of service rendered should be reviewed and justified primarily as the determination of proper operation and maintenance costs. The justification must necessarily extend into the program of capital expenditures, particularly in deciding the beginning of construction on specific major projects.

In attempting to reach a balance, the estimate of revenues for the budget period must be reviewed to determine their sufficiency. If the desired balance is obtained, the mechanics of control can be established.

Too often of late years it has been necessary to consider the reestablishment of rates at a proper level in an effort to keep in step with the rapid changes in the overall economic structure. With a sound determination of the required service level, however, proper rate adjustments have and can be made.

The general quality of utility service rendered is determined, to a great extent, by the rate charged. With the the utilization of a time-period budget for control, the rates thus established for the balancing of the budget will necessarily reflect top-quality operation.

Discussion

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Budgets are difficult to discuss because their application is closely related to the policies of the governing body of a specific plant. The author has presented general principles with specific application to his own organization.

Water plants are operated by several types of organizations and governed by various laws and ordinances. Specific budget control depends, of course, upon compliance with these laws. Cities that have separate boards governing their utilities and utility

districts usually have clearly fixed laws governing the use of their funds. The municipal plants in which policies are determined by the city council, however, have had a wide variety of circumstances governing their operations, making it difficult to comply with a uniform system for financial operation.

One of the greatest budgeting problems arises when the water plant's budget is considered along with the remainder of the municipal budget. There is a tendency to support the other functions of government from the profits of the water department, thereby providing extra services to the people without increasing the tax rate. Unless the department head responsible for water operations is very thorough in the preparation of his budget and presents data that will clearly support his needs, in a language that lay people can understand, he will find himself coming out short because of pressure exerted by other departments.

Advance Planning

The writer would like to emphasize the author's mention of the desirability of advance planning. Of course, no one could have adequately planned for the expansion of the water facilities which is being experienced at present. In normal times, improvements to the plant should be continuously made so that a major replacement program need not be faced later. For example, depending upon the size of the plant, a year's activities in the distribution system might include replacing a few blocks of undersized mains, bringing a few hydrants up to standard, and inserting a few valves. In production facilities, improvements might include replacing a booster pump, constructing a new pumphouse, and replacing a fence. These projects are easy to sell to a governing body when they involve relatively small amounts.

The problem of financing major improvements and extensions to a water utility plant is one that has been faced the last five years and there are no definite signs of the end of this demand. Although it is convenient to have a large sum in reserve to meet such expenditures, most cities are prevented by law from accumulating such funds. The practicability of the accumulation of these funds is questionable as municipalities are restricted in the manner in which these funds may be invested, and consequently, the use of these funds today would have only one-half to one-third the value they had when originally reserved. The writer believes that funds so accumulated should be kept to a minimum to be used for emergencies, and that major improvements and expansions should be accomplished by borrowing money. To sell such a financial program to the people—to convince them this manner of financing is the only businesslike solution to the problem—requires considerable effort by the utility.

Budget Estimates

The problem of resolving a budget, exclusive of capital additions, is a relatively simple task if the plant operates under a uniform system of accounting and maintains good operating records. In estimating sales, the last year's experience alone should not be used, but rather, the average of a 5- or 6-yr period. It is not wise to go beyond the 5- or 6-year period because the habits of the people and the conditions of the community change. In estimating expenditures, a factor that will compensate for increased cost of labor

and materials should be included. If a maintenance program that is out of balance with the past years is proposed, the favorable aspects of the program should be explained in detail.

Unfortunately, the people who finally pass on a financial request seem to have the conviction that all department heads are asking for more money than they actually need. The water department head must be clever in disguising some of his requests so that if cuts in the budget are requested, he can reluctantly reduce certain maintenance accounts on the ground that there may not be as many breakdowns as contemplated, but at the same time, should extract a promise that money will be reappropriated if trouble occurs.

In developing a budget, the estimates of revenue should be very conservative but the maintenance and operating accounts should be a little on the heavy side, thus producing a modest profit. This formula will invariably result, at the end of the year, in a greater profit than anticipated and the water department head will be considered a great manager. If less than the contemplated surplus results, sound, detailed reasons should be given. The best method of coping with a deficit is to keep at least monthly reports so that the governing body can be informed of the unusual circumstances which decreased the revenues or increased the maintenance and operation costs.

The water department head should know the laws that govern his utility and limit its operation, study the factors that influence the governing board, and continue requesting policies that will provide a well-operated and well-maintained utility, so that he can develop a sound system of budget control.

W. C. Renshaw

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Of particular interest to the writer was the author's feat in accomplishing most of his construction program in spite of the loss of a substantial part of the anticipated revenue. The incident illustrates two important functions of budget control—to provide a means of assessing the effect of a change in conditions, and to furnish the basic information necessary to meet the change intelligently.

In spite of its unpleasant associations, almost no one questions the value of a properly constructed budget in utility management. The budget and the control exercised through it provide a plan of operation whereby objectives can be attained and, at the same time, furnish assurance, throughout the budget period, that operations are in accordance with the plan.

The budget is a valuable tool, but like any tool, must be properly designed and used. The effectiveness of the overall control will depend to a large extent on the way in which the budget itself is constructed—the extent to which it lends itself to an intelligent comparison between planned and actual expenditures or revenues from month to month. It is not sufficient to determine from an annual budget that two months are gone and one-sixth of the money spent. Perhaps certain maintenance items, such as those for wells and reservoirs, include sizable expenditures for cleaning during the winter months which are still ahead. In comparing revenues, no more than one-sixth of the year's anticipated water sales in the months of July and August would present not a normal, but a de-

pressing picture. For proper control, a distinction should be made between normal day-to-day expenditures, that may be expected to occur more or less uniformly throughout the year, and those large items which are scheduled for some particular time. For revenue, a basis should be furnished for ascertaining what proportion should have been realized at any particular time. It is also sometimes very convenient to know, in the event a little innocent fraud has been practiced by the insertion of padding here and there, whether a cut has removed only padding, or essential items.

Budget Breakdown

The official budget document, as submitted to the governing body, should not be set up in great detail. In the interest of flexibility, the less detailed it is, within limits, the better. It should be supported by unofficial breakdowns sufficient for adequate control, however. The form that the unofficial breakdowns take is of little consequence. A very small utility in which budget control is essentially a one-man operation may require only a few pencilled notes in the margin. The important thing is that the required information be available in a form that is clear and readily usable without time-consuming calculations.

The author's point concerning the value of a long-term capital expenditure budget deserves particular emphasis. Without some guide to capital requirements, it is impossible to set up an annual budget on a sound basis. At the time the writer took charge of the water department in Inglewood, there was cash in the bank and securities equivalent to a year's gross revenue. The last income statement showed a net income after depreciation of approximately 10 per cent of the gross revenue. The financial outlook was most satisfactory until a 10-yr program of essential replacements and extensions was prepared, at which time the picture changed completely. The long-term capital requirements indicated clearly that the funds on hand plus anticipated income were not sufficient to meet essential capital requirements. A rate increase or some source of additional revenue was urgently required.

Small Utilities

A situation may arise in smaller municipal utilities in which the form of budget does not fit the existing system of accounts. This situation may arise from an understandable desire on the part of the city administration to have the budget requests from all departments submitted in the same form. For most city departments concerned with governmental functions, accounting consists generally of a separation of expenditures by funds, with an object-of-expenditure classification for each fund. As a result, the budget may be set up in the following form:

Salaries

Expense subdivided by object-of-expenditure—office supplies, utilities, janitorial supplies, etc.

Outlays listed by projects or items.

With the normal utility classification of accounts, this form seems to require a separate set of books for budget control purposes. If the expense subdivision can be changed from an object-of-expenditure to a functional basis which does not materially alter the general form, however, it is possible to set up adequate control with a few memorandum accounts and a relatively simple monthly breakdown sheet. In Inglewood, with a gross revenue of about $400,000, it takes a bookkeeper about one day per month to set up and record the information necessary for budget control under this arrangement.

Natural and Applied Fluoridation Census

Task Group E5-10

A report by Task Group E5-10—Committee on Fluoridation Materials and Methods, presented on May 7, 1952, at the Annual Conference, Kansas City, Mo., by O. J. Muegge, Chairman; State San. Engr., Bureau of San. Eng., Madison, Wis.

Task Group E5-10 on Fluoridation, Materials and Methods

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DENTAL caries control through fluoridation of public water supplies is continually gaining impetus. In order to study this trend, Task Group E5-10 on Fluoridation Materials and Methods gathered data from all states and territories, and from provinces of Canada on fluoridation plant installations, populations served, type of chemical and feed equipment used, date of installation, and fluoride residual maintained. Four types of chemical were found in use: sodium fluoride (NaF); sodium fluosilicate, also known as sodium silicofluoride (Na_2SiF_6); hydrofluosilicic acid (H_2SiF_6); and hydrofluoric acid (HF). Thirty-seven states and one Canadian province reported that, as of Jan. 1, 1952, fluoridation plants were being operated on one or more supplies, and the details of these installations are presented in Table 1. Not included in the table are 42 additional installations known to have begun operation in the first three months of 1952. A summary of the plant and population statistics is given in Table 2. The type of chemical that is used in the plants and the feed equipment employed are summarized in Table 3.

The task group also gathered data on the natural fluoride content of water supplies. A number of states, territories, and provinces provided incomplete or no information, stating that surveys had not been made, were incomplete, or that the data had not been compiled. The returns received from 44 states giving some classification of fluoride content have been summarized in Table 4.

Several of the states which did not submit information on the natural fluoride content of communal water supplies are known to have waters high in fluoride. A material change in the number of systems and the population served in the higher fluoride classification may, therefore, be anticipated.

TABLE 1

*Fluoridation Plants in the United States and Canada, Jan. 1, 1952**

Locations Served	Population Served in 1950	Chemical Used				F Residual Maintained *ppm*	Date Installed
		NaF	Na_2SiF_6	H_2SiF_6	HF		
Alabama							
Tuscaloosa	52,734		D			0.75–1.0	6/51
Holt							
Northport							
Arkansas							
Jonesboro	17,692	D				1.0	10/51
Nettleton							
Little Rock	146,310	D				1.0	4/51
N. Little Rock							
California							
Rio Vista	1,831		D			1.0–1.2	10/51
Colorado							
Grand Junction	14,435		D			1.0	7/51
Connecticut							
Cromwell Fire District	2,500	St				1.0	6/51
Mansfield State Tr. School	1,700	S				1.0	11/50
New Britain	78,000	D				1.0	12/50
Southbury State Tr. School	1,800	S				1.0	4/45
Delaware							
Newark	6,731	S				1.0–1.2	1950
Florida							
Clewiston (P)	2,499		D			0.6–1.1	10/51
Gainesville	26,861	D				0.6–1.1	10/49
Mt. Dora	3,028	S				0.6–1.1	10/50
Naples	1,465	D				0.6–1.1	10/51
Georgia							
Athens	28,180	D				0.7	1951
Dekalb County	110,000		D			0.7	1951
Idaho							
Lewiston	12,985	D				1.0	6/47
Illinois							
Assumption	1,466	S				1.0	9/51
Chester	5,339		D			1.0	12/51
Evanston	73,641	D				1.0	2/47
Indiana							
Columbus	18,370		D			1.0	12/51
Fort Wayne	133,607		D			1.0	7/51
Huntingburg	4,057		D			1.0	8/51
Indianapolis (P)	439,137	D				1.0	8/51
Beech Grove							
Ben Davis							
Mars Hill							
Southport							
Woodruff Pl.							
Zionsville	1,536	S				1.0	11/51
Iowa							
Dubuque	49,671	D				1.2	10/51
Waukon	3,158	S				1.2	10/51
Kansas							
Horton	2,900			S		1.0	1951
Ottawa	10,000	S				1.0	1946

* Key to symbols and abbreviations in table: P—privately owned utility; S.D.—sanitary district; D—dry feed equipment; S—solution or slurry feed equipment (slurry feed is applicable only to sodium fluosilicate installations); St—saturator type feeder; Sd—oil displacement type feeder.

TABLE 1—*Continued*

Locations Served	Population Served in 1950	Chemical Used				F Residual Maintained ppm	Date Installed
		NaF	Na_2SiF_6	H_2SiF_6	HF		
Kentucky							
Elizabethtown	5,800		D			1.2	7/51
Greensburg	1,000			S		1.2	4/51
Hopkinsville	12,500	D				1.2	8/51
Louisville	370,000		D			1.2	8/51
Maysville (P)	8,700		D			1.2	4/51
Maryland							
Hagerstown	43,119		D			1.0	12/51
Canetown							
Funkstown							
Halfway							
Roxbury Penal Farm							
Security							
Smithsbury							
Williamsport							
Washington Suburban S.D. (26 incorporated and approx. 26 unincorporated areas in Montgomery and Prince Georges Counties)	310,000		D			1.0	12/51
Massachusetts							
Belchertown State School	1,283	S				1.0	12/46
Danvers	18,500		D			1.1	5/50
Middleton							
Templeton	4,100		D			1.0	1/51
Wrentham State School	1,968	S				1.0	12/46
Michigan							
Algonac	2,607		D			1.0	9/49
Ann Arbor	47,279		D			1.0	12/51
Battle Creek	48,469	D				1.0	4/51
Benton Harbor	18,769	D				1.0	9/51
Grand Rapids	175,647	D				1.0	1/45
Grosse Pte. Farms	9,365		D			1.0	5/51
Hastings	6,060		D			1.0	1/51
Jackson	50,904		D			1.0	8/51
Kalamazoo	57,704	D				1.0	8/51
Ludington	9,066	S				1.0	12/49
Marquette	17,345		D			1.0	9/51
Midland	14,202		D			1.0	1/46
Monroe	21,467		D			1.0	12/51
Mt. Clemens	16,815		D			1.0	3/51
Muskegon	48,047	D				1.0	7/51
Negaunee	6,472		D			1.0	11/51
Saginaw	92,352		D			1.0	5/51
Wyandotte	36,666		D			1.0	1/51
Minnesota							
Benson	3,398	S				1.2	12/51
Fairmont	8,193		D			1.2	4/51
Fergus Falls	12,917		D			1.2	4/51
Hallock	1,552		D			1.2	12/51
Red Lake Falls	1,733	S				1.2	4/51

* Key to symbols and abbreviations in table: P—privately owned utility; S.D.—sanitary district; D—dry feed equipment; S—solution or slurry feed equipment (slurry feed is applicable only to sodium fluosilicate installations); St—saturator type feeder; Sd—oil displacement type feeder.

TABLE 1—*Continued*

Locations Served	Population Served in 1950	Chemical Used				F Residual Maintained *ppm*	Date Installed
		NaF	Na_2SiF_6	H_2SiF_6	HF		
Thief River Falls	6,926		D			1.2	12/51
West Concord	770	S				1.2	12/51
Winnebago	2,127	S				1.2	4/51
Mississippi							
Columbus	17,170		D			1.0	18/5
Nebraska							
Beatrice	11,813		D			1.2	4/51
Superior	3,227	D				1.2	7/51
New Jersey							
Morristown	25,000	S&D				1.0–1.2	1950
Hanover Twp.							
Morris Plains							
Morris Twp.							
New York							
Newburgh	32,000	D				1.0	5/45
New Rochelle	100,000	D				1.0	10/51
Ardsley							
Bronxville							
Eastchester							
North Pelham							
Pelham							
Pelham Manor							
Tuckahoe							
Olean	25,000		S			1.0–1.2	11/51
North Carolina							
Charlotte	145,000		D			0.6–1.1	4/49
Winston-Salem	100,000		D			0.8–1.2	10/51
North Dakota							
Northwood	1,168	S				1.2	11/51
Ohio							
Avon Lake	4,342			S		1.0	12/51
Lisbon	3,293			S		1.0	10/51
Westerville	4,112	S				1.0	6/51
Oklahoma							
Nowata	3,965		D			1.2	8/51
Oregon							
Gearhart	568	S				1.0	7/51
Pennsylvania							
Brookville	4,600	D				1.2	9/51
Ebensburg	5,000	D				1.2	12/51
Ford City	6,500	D				1.2	6/51
South Carolina							
Fort Mill	3,100		D			1.0	5/51
Hartsville	5,400	S				1.0	8/51
Ninety-Six	3,000	St				1.0	8/50
South Dakota							
Aberdeen	22,011		D			1.2	3/51
Tennessee							
Brownsville	4,668		D			1.0	5/51
Milan	4,941	D				1.0	3/51
Texas							
Breckenridge	6,605	D				1.2	4/51
Corpus Christi	108,053	D				1.1	4/50

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TABLE 1—*Continued*

Locations Served	Population Served in 1950	Chemical Used				F Residual Maintained *ppm*	Date Installed
		NaF	Na_2SiF_6	H_2SiF_6	HF		
Graham	6,756	D				1.2	5/51
Iowa Park	2,115	D				1.0	9/51
Marshall	22,255	D				1.0	5/46
Sweetwater	13,580	D				1.0	9/51
Temple†	24,970	D				1.0	4/51
Wellington	3,669			S		1.0	9/51
Wichita Falls	67,709	D				1.0	7/51
Virginia							
Charlottesville	30,000		D			1.0	11/51
Lynchburg	55,000		D			1.0	9/51
Madison Heights							
Washington							
Kennewick	10,085	D				1.0	12/50
West Virginia							
Ripley	2,000	S				1.0	5/51
Weirton	27,000		D			1.0	1/51
Wheeling	62,000		D			1.0	9/50
Wisconsin							
Antigo	9,902	D				1.1	6/49
Appleton	37,300		D			1.0	10/50
Belle Heights S.D.							
Bucholz S.D.							
Whispering Pines S.D.							
Ashland	10,640		D			1.2	10/49
Athens	823	S				1.1	3/51
Baraboo	7,430		D			1.2	5/49
Lyons S.D.							
Beaver Dam	11,867	D				1.2	3/51
Belleville	735	S				1.0	8/51
Beloit (P)	29,590		D			1.0	4/49
Berlin	4,693	St				1.2	10/51
Blair	873	S				1.3	7/51
Bloomer	2,556	S				1.0	8/50
Cambridge	552	St				1.1	6/51
Columbus	3,250	D				1.3	8/50
Eagle River	1,469			S		1.2	6/51
Eau Claire	36,058	D				1.2	1/51
Edgar	705	S				1.0	11/49
Edgerton	3,507		D			1.3	10/50
Elkhorn	2,935	S				1.0	4/48
Elroy	1,654			S		1.1	7/51
Evansville	2,531		D			1.0	3/50
Fond du Lac	29,936		D			1.1	7/50
Fort Atkinson	6,280	St				1.0	12/49
Galesville	1,193	S				1.2	9/51
Hartford	4,549	S				1.2	1/50
Hayward	1,577			S		1.1	6/51
Janesville	24,899	S				1.1	2/49
Lake Geneva	4,300		D			1.1	5/51

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† Temple, Tex., because of a shortage of its surface supply source, is presently augmenting its supply by using fluoride-bearing ground water in sufficient amounts to maintain an effective fluoride water in the combined supply.

TABLE 1—*Continued*

Locations Served	Population Served in 1950	Chemical Used				F Residual Maintained *ppm*	Date Installed
		NaF	Na_2SiF_6	H_2SiF_6	HF		
Madison	102,325				Sd	1.0	6/48
Burke S.D.							
Garden Homes S.D.							
Maple Bluff							
Monona							
Shorewood Hills							
Crestwood S.D.	1,200	S				1.0	10/50
Marinette	14,178		D			1.0	3/51
Marshfield	12,394		D			1.1	10/50
Mayville	3,010	St				1.0	9/50
Mazomanie	963	S				1.4	9/51
Menasha	12,385		D			1.1	8/50
Menomonee Falls	2,469			S		1.3	9/51
Middleton	2,275	S				1.2	6/50
Middleton S.D.							
Mukwonago	1,207	S				1.0	5/49
Neenah	12,437		D			1.0	3/50
Neopit	1,257	S				1.0	1/51
Oregon	1,341	S				1.1	2/50
Orfordville	543			S		1.0	9/51
Oshkosh	41,084		D			1.1	1/50
Phillips	1,775	S				1.1	11/50
Platteville	5,751		D			1.2	10/51
Portage	7,334	S				1.2	3/51
Port Washington	4,775		D			1.3	9/50
Prairie du Sac	1,402			S		1.0	10/51
Racine	71,798		D			1.0	3/50
South Lawn S.D.							
Reedsburg	4,072	D				1.1	2/50
Rhinelander	8,774			S		1.1	5/50
Richland Center	4,608	D				1.2	12/49
Ripon (P)	5,619		D			1.4	6/51
Sheboygan	45,964	D				1.1	2/46
Sheboygan Falls							
Soldiers Grove	781	S				1.0	1/50
Sparta	5,893			S		1.1	10/51
Spring Green	1,064			S		1.2	12/51
Stoughton	4,833	D				1.2	9/49
Sun Prairie	2,263		D			1.2	3/50
Tomahawk	3,534			S		1.1	6/51
Watertown	12,417		D			1.2	12/50
Waunakee	1,042	D				1.0	4/51
Waupun	6,725		D			1.2	11/50
West Bend	7,888		D			1.0	8/50
Barton							
Westby	1,491	S				1.1	2/51
Whitehall	1,379	S				1.1	6/51
Wisconsin Rapids	13,496	D				1.2	1/51
WYOMING							
Sheridan	11,400	D				1.0	5/51
ONTARIO, CANADA							
Brantford	40,000	D				1.2	6/45

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TABLE 2

Summary of Fluoridation Plant Census

United States					Canada	
Year	No. States With Plants	No. Water Systems Served	No. Communities Served	Cumulative Population Served*	No. Water Systems Served	Cumulative Population Served
1945	3	3	3	209,447	1	40,000
1946	7	9	9	301,520	1	40,000
1947	9	11	11	388,146	1	40,000
1948	9	13	18	493,406	1	40,000
1949	11	27	33	777,033	1	40,000
1950	16	62	78	1,384,153	1	40,000
1951	37	172	240	4,410,079	1	40,000

* Populations based on 1950 census statistics.

TABLE 3

Fluoride Chemical and Type of Equipment

Chemical	Total Plants	Solution Feed Units	Dry Feed Units
Sodium fluoride (NaF)	91*	47	45
Sodium fluosilicate (Na_2SiF_6)	66	1	65
Hydrofluosilicic acid (H_2SiF_6)	15	15	
Hydrofluoric acid (HF)	1	1	

* One system uses both dry and wet feed units.

TABLE 4

Natural Fluoride Content of Water Supplies in U.S.

Fluoride Content *ppm*	No. States Reporting	No. Water Works Systems	Population Served 1950
Unknown	24*	2,768	6,508,930
Less than 0.69	44	10,506†	87,736,609
0.70 to 0.99	38	524	2,031,900
1.00 to 1.49	35	424	1,025,578
1.50 to 1.99	24	170	427,119
2.00 to 2.99	28	171	405,125
3.00 or more	23	112	298,425

* Includes only states making classification.

† Does not include systems served by fluoridation plants, all of which have natural fluoride content in this range.

Design and Construction of the Greater Winnipeg Water District Booster Pumping Station

By N. S. Bubbis and H. Shand

A paper presented on May 22, 1951, at the Canadian Section Meeting, Winnipeg, Man., by N. S. Bubbis, General Mgr., and H. Shand, Engr., both of the Greater Winnipeg Water Dist., Winnipeg, Man.

THE Greater Winnipeg Water Dist. has completed the construction of a booster pumping station, the first major addition to its works since the aqueduct was completed and put into operation in 1919. This paper discusses the factors which had to be considered in planning this addition and describes the new station as it was finally constructed (Fig. 1).

Winnipeg is now using its third source of water supply. The first was installed in 1880 and used the water from the Assiniboine River. In 1900 the source of supply was changed to artesian wells. By 1906 it was evident that the well supply would not be adequate for Winnipeg's rapidly increasing population and industries. A water supply commission was established to develop a supply adequate to the city's needs. Between 1906 and 1912 a number of engineering reports were made and studied, finally leading to the approval by the public utilities commission of an aqueduct to be built from Shoal Lake. A recommendation was also made that the adjacent municipalities join in the project so that they, too, could be supplied from this source.

The district comprises and supplies water to the cities of St. Boniface and Winnipeg, the municipalities of East and West Kildonan, St. James, St. Vital, Fort Garry, and the towns of Tuxedo and Transcona (Fig. 2). The municipalities of North Kildonan, Charleswood, and Brooklands, although not in the district, are supplied with water under special agreements. The district sells water in bulk, not under pressure, to all the municipalities.

To deliver water to the outside municipalities, the district uses the distribution systems of Winnipeg and St. Boniface and pays these cities for the use of their mains. This arrangement relieves the district of the cost of direct connections from the aqueduct.

Winnipeg operates two pumping stations. The residual pressures at the perimeter of the city are used to supply the outlying municipalities of East and West Kildonan, St. James, Fort Garry, North Kildonan, Charleswood, Brooklands, and the town of Tuxedo. These municipalities reimburse Winnipeg for the cost of pressure. In like manner, St. Boniface supplies pressure to St. Vital. Transcona operates its own pumping station.

Water Supply Plans

There are three steps that must be taken in planning a water supply for a community.

1. Present and future requirements must be determined as accurately as possible. This means that future populations must be predicted as well as the increase in per capita consumption which may result from increased domestic and industrial usage.

2. A suitable source of water that will be adequate for future requirements must be located. If several sources are available, the most economical one must be determined from the cost of conveying and treating the water.

3. The works must be planned to give the most economic results. Usually this aim involves an investigation into the possibility of constructing the facilities in steps over a period of years as the demand on the system increases.

Those familiar with water supply planning know that each of these steps presents its own problems and that the solutions are not easily found.

The population of Winnipeg proper increased rapidly from 50,000 in 1902 to 213,000 in 1914. The consultants predicted future flows on the basis of this rapid growth. Actually there was a decline in population in 1915, partly as a result of World War I, but principally because of the opening of the Panama Canal which permitted water transportation to reduce greatly Winnipeg's position as the distributing center for western Canada. It was not until 1931 that Winnipeg's population reached the 1915 figure, and by 1950 it had increased to only 239,000.

Having determined the water demand that would be required and the source of supply, the next step was to design the works that would carry the water from Shoal Lake to Greater Winnipeg. One of the basic reasons for selecting the lake rather than the Winnipeg River was the 300-ft difference in elevation between Shoal Lake and Winnipeg. The design was therefore based on making the greatest possible use of this head. Another important factor was the balancing of merits of single and duplicate pipelines. From Shoal Lake to a point about 42 miles east of Winnipeg, the aqueduct had to be built over a swampy, barren, and uninhabited area. Figure 3 shows the consultants' estimates of future rates of water consumption and population growth.

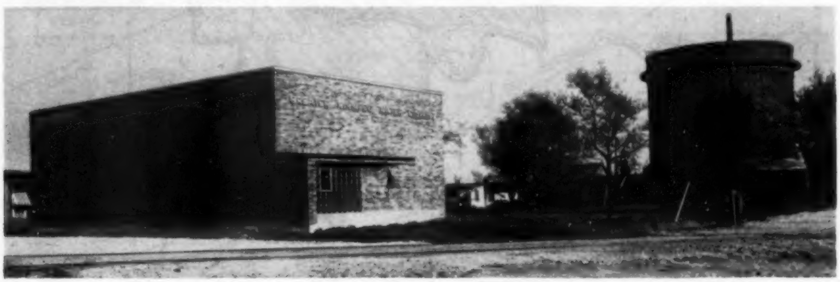

Fig. 1. Winnipeg Booster Pumping Station and Surge Tank

Aqueduct Construction

The intake structure of the aqueduct takes water from Indian Bay, an extension of Shoal Lake and the Lake of

the Woods, and conveys it to the McPhillips St. Reservoir, a distance of 96.5 miles. The aqueduct is built almost entirely of concrete and varies both in cross section and discharge capacity. At present it cannot deliver to the Greater Winnipeg area the 85 mgd * for which its main section is designed.

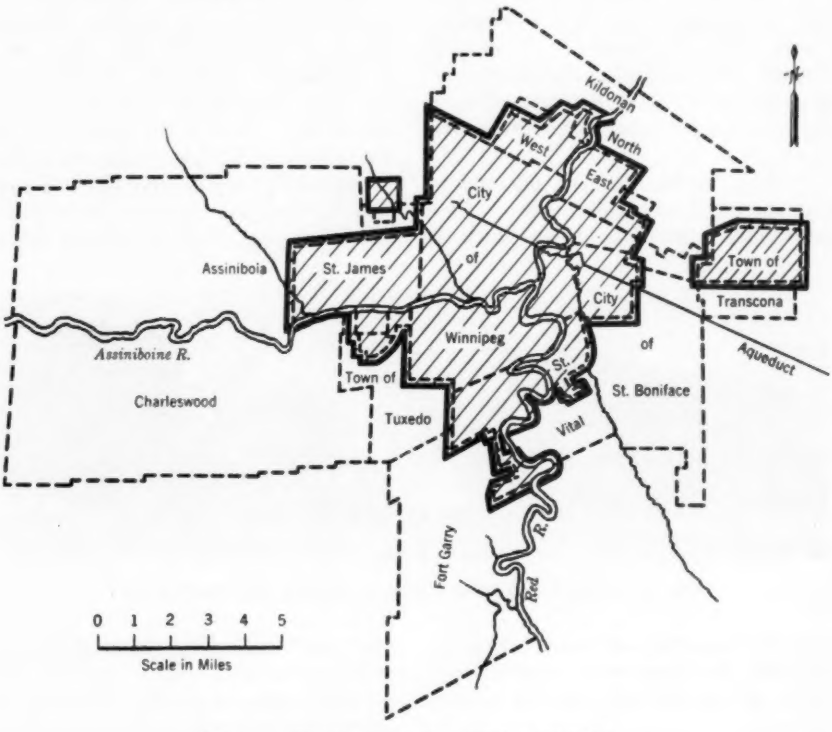

Fig. 2. Greater Winnipeg Water District

The Winnipeg Water Dist. also supplies the outlying municipalities shown.

The open flow section, constructed mainly of plain concrete, extends westward from the intake for about 80 miles, and has a discharging capacity of 85 mgd. From the west end of this horseshoe-shaped section there is a depressed section of reinforced concrete 8 ft in diameter and 4 miles long, which continues the discharging capacity of 85 mgd to Deacon, the site chosen for a future 250-mil gal reservoir. Deacon is about 9.5 miles from the surge tank on the east bank of the Red River. Between these points there is approximately 49,000 lin ft of 5.5 ft reinforced concrete pipe which has a discharging capacity of approximately 50 mgd.

A 5-ft tunnel crosses the Red River and 11,659 ft of reinforced-concrete pipe, 4 ft in diameter, 28.5-mgd capac-

* Gallons throughout this paper refer to the Imperial gallon, which equals 1.2 U.S. gal.

ity, extends through the city of Winnipeg to the reservoirs at McPhillips St.

There are four overflow structures at points 83, 74, 64 and 43 miles from Winnipeg, each provided with stop-log grooves across the aqueduct with a discharge weir 20 ft long built into the side of the pipe. These are located up-

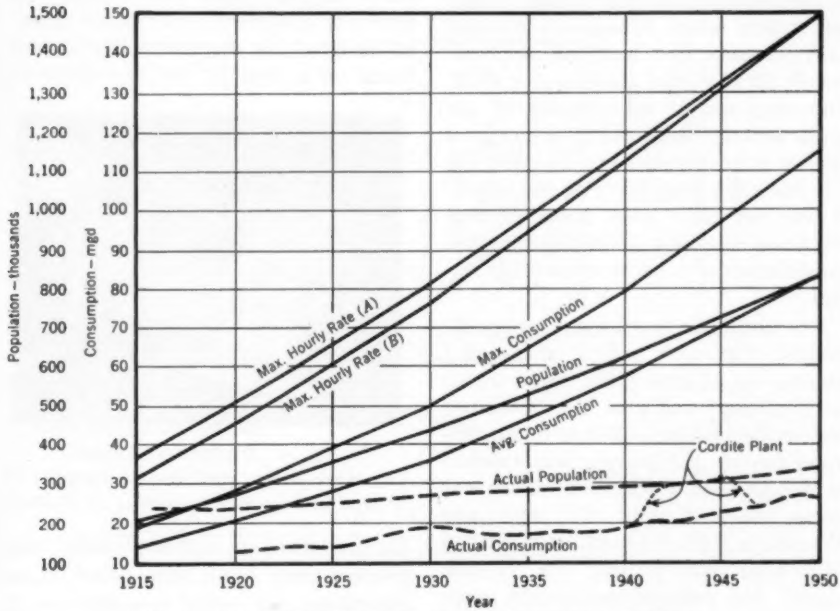

Fig. 3. 1917 Water Consumption and Population Estimates

The two broken lines give the actual population and consumption for the period from 1912 to 1950. Maximum Hourly Rate (A) includes fire streams and Maximum Hourly Rate (B) excludes fire streams.

stream from river crossings so that, when necessary, part or all of the flow may be diverted into a river. Another overflow is located at the west end of the open flow section 17 miles from Winnipeg. This overflow automatically protects the gravity section of the pipe from any internal pressure which might develop if the incoming flow exceeded the requirements of the district. The offtake ditch from this structure is 11 miles long, and is maintained, together with all the bridges that cross it, by the district.

The Red River is crossed at approximately 80 ft below ground surface by cast-iron pipe 5 ft in diameter which is set within vertical shafts lined with concrete and within a concrete-lined horizontal rock tunnel 10 ft square. A reinforced concrete surge tank is built on the aqueduct on the east bank of the river near the tunnel crossing. The surge tank protects the circular reinforced-concrete pressure section of the aqueduct extending eastward from St. Boniface from excessive pressures which might result from the closing of the valves that control the discharge of water into the city's reservoirs. Every

precaution was taken to prevent surge. It is noteworthy that no gates were placed in the entire line.

Predicted Future Flows

The plan of the consultants as adopted was to construct the works in a series of steps. The first step was to be the construction of a booster pumping station when Winnipeg's average daily consumption reached approximately 25 mgd, the estimate for 1922. This step was to be followed by the construction of a second 5½-ft line from Deacon to St. Boniface and a second 4-ft line from the Red River to Winnipeg. It was not until 1948, however, that the flows reached a point requiring the construction of a booster pumping station.

The consulting engineers' report estimated that with a flow of 30 mgd passing the 17-mile point, there would be 28.5 mgd available for Winnipeg and its dependents. When this maximum day of 28.5 mil gal was reached at Winnipeg in 1948, St. Boniface was being supplied with 4.7 mgd and Transcona with 1.0 mgd, or a total of 34.2 mgd was passing the 17-mile point. The reduced head at the surge tank at this rate of flow was not sufficient to deliver 28.5 mgd to a full reservoir at McPhillips St. This amount was supplied to Winnipeg only because domestic pumps were installed in 1926 at the James Ave. pumping station located at the west end of the tunnel section. While this station was operating, to the extent of its pumping rate, it relieved the 4-ft pipe.

The maximum daily output reached by the Winnipeg pumping stations in 1949 was 32.5 mil gal which exceeded the input by 3.0 mil gal. The 3-mil gal deficiency was supplied from storage. Protracted hot weather would soon seriously deplete the usable storage, although as the level of the reservoirs falls, the ability of the district to supply water under gravity conditions increases.

In 1949 it was decided to investigate and reassess the water supply problem in the light of current conditions and to revise the program of future development. The future population trend for the entire district was based on a straight line projection of the growth of the last ten years. The average daily flows were based on an increasing per capita consumption of from 80 in 1950 to 100 gpd in 1970. The flow requirements, pipe sizes, and program of future development are based on the maximum daily flow which is 1.35 times the average rate of flow. The storage required to meet the maximum hourly rates will be supplied by the municipalities.

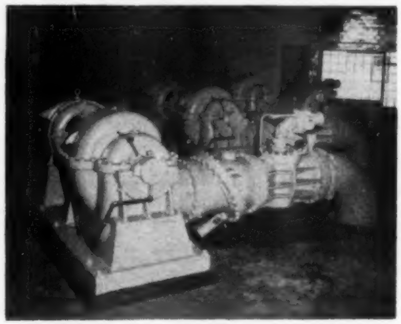

Fig. 4. Centrifugal Pumps
The three pumps each have a capacity of 20 mgd and operate against a 30-ft head.

This program required the building of a booster pumping station in 1950, and a second 5½-ft pipe to St. Boniface and a second 4-ft pipe to Winnipeg by 1964. From 1964 to 1976 Winnipeg and dependents would again be supplied by gravity and after 1976, by increased booster pumping.

Station and Pump Design

Preliminary studies of the new station were started in 1948 and completed in 1949. Of the 50 mgd available from Deacon, it is estimated that about 7.5 mgd will be required by St. Boniface, St. Vital, and Transcona, leaving 42.5 mgd to serve Winnipeg and its dependent municipalities.

The selection of the number and capacity of the pumps for immediate installation was influenced by the anticipated needs of Winnipeg for the next 10 to 15 years and by the connected load charge, which would far outweigh the cost of power used in operation. The final choice was to equip the station with three pumps each having a capacity of 20 mgd to operate against a 30-ft head (Fig. 4). Only two of these, which will deliver approximately 40 mgd, will be required at present. The connected load charge is applied to two pumps only. A selector switch on the board permits the use of any two of the three pumps at one time, thus reducing the connected load charge to 300 hp. As the demand increases, three units could be used to deliver about 42.5 mgd against a 38-ft head. Provision has been made for the installation of a fourth pump, the same size or possibly larger, in order to expand the station to the ultimate capacity of the existing $5\frac{1}{2}$-ft line. The three centrifugal pumps installed were of the bottom-suction side-discharge type, and were connected directly to

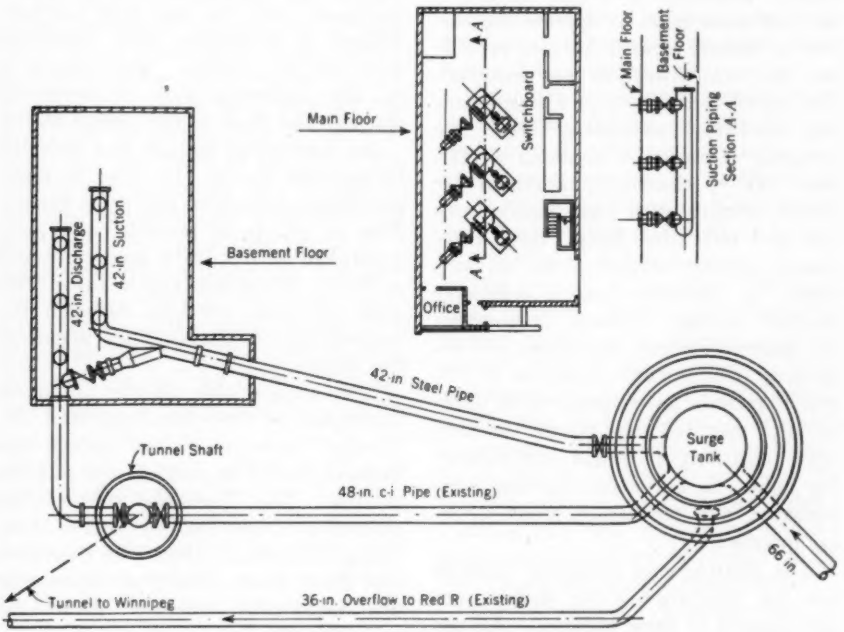

Fig. 5. Piping Layout

The 48-in. cast-iron pipe supplies Winnipeg with water by gravity. The 42-in. gate valve supplies the new booster station with water.

150-hp, 550-v, 3-phase, 588-rpm, squirrel-cage motors. Pumps were selected on the basis of overall efficiency, initial cost, actual horsepower required, and operating cost.

Switchboard and Motors

Consideration was given to both manual and electrical operation of the board. Inasmuch as it may be necessary, at some time, to operate the station by remote control, a board providing electrical operation was installed. The board is made up of a free-standing, dead-front switchboard with five cubicles. Cubicle A contains a 600-amp, 600-v, electrically operated air circuit breaker with push button control and indicating lights, three 600/5-amp current transformers, an ammeter, a voltmeter, and a voltmeter transfer switch. Cubicle B contains the water metering, recording, and indicating equipment. Cubicles C, D, and E contain a 400-amp, 600-v, electrically operated air circuit breaker with push-button control and indicating lights, an automatic starting compensator, and mechanical and electrical interlocks.

The starting and reversing controls for the discharge valve motors are also housed in these cubicles. All the push buttons for the pumps and valves are grouped together on Panel B. Provision is made to control a future pump. A selector switch limits the use at one time to any two of the three pumps or to electric heating.

Piping and Valves

The piping arrangement is shown in Fig. 5. In the original layout at the surge tank two points were provided through which water could be delivered. One was a 48-in. cast-iron pipe leading directly to the east tunnel shaft. This pipe has been used to supply Winnipeg and its dependents with water by gravity. The other was a 42-in. gate valve placed for the use of a future booster station. This point supplies the new station with water. All the main piping, both suction and discharge, is of welded-steel construction, 42 in. in diameter with ½-in. wall thickness. All the steel pipe was fabricated in accordance with Specification AWWA C201. This piping is in the basement and is connected through the floor to the pumps above.

An interesting feature was included in the pipe layout. In order to make the change-over from gravity to booster flow as simple as possible, a by-pass controlled with a 36-in. gate valve and a 36-in. tilting-disk check valve with dash pot was provided between the suction and discharge lines ahead of the pumps.

The suction side of the pumps is controlled by three hand-operated, 24-in. cone valves set in the vertical line between the 42-in. suction pipe and the pumps. The discharge side of the pumps is controlled by three 24-in. tilting-disk check valves with dash pots and three 24-in. cone type valves that are electrically operated from the switchboard.

The 2 miles of 4-ft reinforced-concrete pipe from the tunnel shaft to the reservoirs was designed for a head of 100 ft. An investigation of possible water hammer or vacuum under the new discharge conditions was made. It was found that with the by-pass arrangement described, no adverse conditions should be experienced and no shock was expected in excess of the strength of the pipe. Provision has been made, however, by a blanked flange inserted into the discharge pipe,

to install a damping device if it becomes necessary.

Dresser couplings were installed at various points in the line to simplify erection and to provide some flexibility and the opportunity of dismantling sections when required.

Steel Pipes and Coatings

Winnipeg's experience with underground steel pipe has not been a happy one. In the early years of the century, before the advent of the water district, the city laid much steel pipe for the collection of water from a series of wells that lay north of the city. The soil in the Winnipeg area is high in sulfates, and these salts soon took their toll on a steel pipe that had only a dipped coating for protection from corrosion. As a result of this and other experiences, little underground steel pipe has been used in the Winnipeg area for the last 50 years. The improvements in the methods of coating and wrapping steel pipe within the last decade, the weight advantage of steel over cast-iron pipe, and the flexibility and ease of fabricating fittings, however, led the district to select steel pipe for the booster pumping station.

The firm that was awarded the contract for the installation and supply of steel pipe has had much experience in rolling and assembling steel plates. The actual construction of the pipes and fittings was completed accurately and quickly, but the firm did not have the proper equipment nor experienced men to apply the coal-tar coating. The contractor studied an excellent, photographically illustrated handbook on the placing and testing of these coatings, which was furnished by the manufacturer, and as a result made up his own heating kettles and an electric "jeep" or "holiday" detector to check and locate any breaks in the coating.

The jeep consisted essentially of a source of d-c potential of from 8,000 to 10,000 v at low amperage. The source of supply was grounded to the pipe and the output was connected to an insulated lead terminating in a "cats whisker" arrangement. In use, the whisker was brushed across the enamel surfaces and the "holidays" were pin pointed by the crack and flash of the arc to the grounded pipe.

The pipe coating conformed to Specification AWWA C203, and was applied to the entire pipe interior and to the exterior surfaces of the length to be buried in the soil. The exterior was further protected with a bonded wrap of asbestos felt paper.

The enamel was applied by hand, using daubers. Each application of the dauber produced a shingle approximately $3 \times 6 \times \frac{1}{16}$ in. thick. These shingles were applied circumferentially in the first coat and longitudinally in the second. Great care was necessary to obtain the proper bonding at the lapping edges of successive shingles. Each length was jeep-tested and repaired at the factory and again on the job after completing the installation.

The asbestos-felt wrapper was applied circumferentially in 4-ft strips, 12 in. wide. Each strip was dipped in enamel and applied with the daubers while still hot. Successive strips were lapped at sides and edges and the bond was checked. If a flaw was found in the coating or wrapping, it was removed and reapplied.

Flowmeter

The primary element of the flowmeter is a 42-in. eccentric type orifice plate installed in the suction pipe as it enters the building. The recording

and indicating elements are mounted on the metering panel of the switchboard. The weekly chart records the rate of flow, the pump discharge pressure, and the level of the water in the surge tank. A 12-in. diameter indicator measures the rate of flow and another 12-in. indicator shows the level of the water in the surge tank. The water level indicator, as the water falls toward the minimum allowable elevation, first flashes a warning green light and on reaching the low level, flashes a red light and sounds a Klaxon horn. Thus, the operator is warned that the pumps are discharging more water than is being supplied and must be throttled until more water is made available from the intake.

Building Construction

Plans for the new station were completed in 1949 and contracts were awarded in the fall of 1949 for the building and for all equipment. Borings at the site of the station indicated a poor subsoil, mainly made up of water-bearing river silt and sand down to the hard pan overlying the rock. Poured concrete piles could not be used in these conditions and Douglas fir wood piling was specified for the building.

The 42-in. suction pipeline was supported on a well-compacted gravel bed. The grade for the discharge pipe was lower and in a strata of less stable soil. The spring floods had aggravated this condition and it was felt that the soil could not be relied upon to withstand the dead load of the full pipe and the vibration and thrust from the pumps. The pipe was supported by steel saddles framed between five 8-in. steel H piles driven to the hard pan.

The building was framed in steel with hollow tile curtain walls, faced outside with tapestry brick and inside with glazed tile. A precast concrete-slab roof was cork insulated and given a tar and gravel topping. Steel beams connected to the wall columns carry a manually operated 3-ton traveling crane. Glass brick panels in the south and west walls provide a pleasing light and the buff wall tiles contrast favorably with the green concrete floor and green slab doors.

Construction work on the building proceeded throughout the winter and by May 1, 1950, it was complete with the exception of the glass brick and some inside tile finishing. In the meantime as the Red River had passed flood stage, the effort to keep the basement dry by pumping was abandoned on May 5, and the basement filled with clean water. The river reached its maximum elevation on May 19 with the water 18 in. above the main floor. The possibility of floods had been taken into consideration in designing the station. The elevation of the pumps had been set as high as possible in relation to the suction conditions in the surge tank. One of the new dikes constructed after the flood now protects the station.

The engineering staff of the district selected the equipment and was responsible for the hydraulic features of the design, and the architectural firm of Green, Blankstein, Russell, & Assoc. designed the building.

It is expected that for the next few years the station will be operated intermittently during the summer, and, as a result, the heating arrangement and temperature and burglar protection are somewhat unusual. Heating is supplied by an automatic oil-fired steam boiler and also by thermostatically controlled electric unit heaters. Electric heaters are used to supple-

TABLE 1

Pump Performance

Pump	Quantity *mgd*	Height *ft*	Pump Efficiency *per cent*	Brake Horsepower	Amount Above Rated Horsepower *per cent*	Max. Horsepower From Curve	Amount Above Rated Horsepower *per cent*
1	20	34.5	92.0	158	5.3	159.2	6.1
2	20	35.0	91.5	161	7.3	164	8.6
3	20	34.7	91.0	161	7.3	164	8.6

ment the steam boiler because, for the next few years, the annual minimum charge for the connected load will far exceed the cost of power consumed for pumping, thus allowing the district to employ the unused portion of the connected load charge for electric heating. The station is fully protected against burglary and vandalism by an alarm system installed by a protection agency. In addition, a thermostat is incorporated in the system that will sound an alarm at the agency's office should the temperature in the building fall below 40 F, thus enabling the heat load to be kept to a minimum.

Pump Testing

The construction and installation work was not completed until November, 1950. It was then too late in the season to test the station as a whole so the testing was deferred until the summer of 1951. The quantity of water was measured by the eccentric orifice meter in the 42-in. diameter suction pipe. This meter was checked and rechecked by the manufacturer's representative with a mercury manometer directly across the orifice and was found to be correct. The electrical instruments were supplied and checked by the city hydroelectric plant and the phase angles were checked at the pump station. The phase angle check brought to light an error in wiring which was corrected. The head was read from a differential U-tube manometer and checked by pressure gages. The pressure gages usually read below the U-tube and varied from 0 to 4 per cent. Every attempt was made to take all readings simultaneously. The discharge valve was set to give the required quantity and for any particular setting of the valve the quantity remained fairly steady.

The guaranteed performance of all pumps was at an efficiency of 87 per cent when the head was 30 ft and the quantity pumped 20 mgd. The brake horsepower under these conditions was 149. The motors supplied were rated at 150 hp with an efficiency of 91 per cent. The results obtained at a 20-mgd rate are given in Table 1. The service factor of the motors, which can be operated continuously at 15 per cent overload, is 1.15. The district accepted pumps of a slightly higher head than was required. The actual horsepower required at all points on the performance curve is well within the guaranteed 15 per cent continuous overload. The foregoing tests were made on individual pumps. Satisfactory final tests were also made on two pumps working in parallel.

Future Plans

In May of 1951, a committee was set up composed of members of the en-

gineering staffs of the district and the city of Winnipeg, to make a study of water works improvements for the district and the city. In October 1951, the committee recommended a 20-yr expansion program. Locations and sizes of feeder mains to be constructed in each of four 5-yr periods with estimates of cost were given. Also included in this report was an estimated cost of a second aqueduct from Deacon to the south boundary of Winnipeg, at the site of Winnipeg's future reservoir and pumping station. This second pipeline will probably be built by the district in 1965.

The city engineer of Winnipeg has recommended to the Utilities Committee of the City Council that the part of the program affecting the city of Winnipeg be executed immediately. A report is being prepared by the general manager and treasurer of the district on the engineering and financial aspects of the scheme as they pertain to the water district.

Conclusion

The completion of the booster pumping station marks another forward step in the development of Winnipeg. Looking back, one cannot help but marvel at the courage and foresight of those responsible for the construction of this water supply system which provides water for approximately one-third of the population of the province and without which this community could not have reached its present size nor looked ahead to any future growth. For nearly 32 years, millions of gallons of water have been flowing into greater Winnipeg without any pumping cost. The district has been fortunate that, during this time, not a single stoppage has occurred as a result of structural failure. Time alone will show whether the authors' predictions of future population and consumption and the program of expansion will be any better than the forecast the consultants made in 1917.

Percolation & Runoff

STEAK—beef, sirloin, tenderloin, sizzling, tasty, thick, charcoaled, rare, juicy, choice, savory, succulent KC steak—must have kept at least 21 water workers at the meating instead of the meeting. At any rate, that's the number by which the official registration at AWWA's Kansas City Conference last month fell short of Philadelphia's 1950 record. But anyone who says KC '52 was anything short of record in any respect is giving you a bum steer; and the 1,986 rabid beefeaters statisticized on page 2 will testify that bum steer and KC are not to be mentioned in the same bite.

More than just a carnival for carnivores, though, KC '52 was fun for all—fun and fact and fellowship—even for vegetarians. The recipe: take 145 boothsful of the finest and shiniest in water works equipment, products of 87 different AWWA manufacturers; add 16 sessions loaded with the latest and best data on everything from rainmaking to flood control, presented by 90 speakers and up to 1,510 other experts in the field; saturate with peerless KC hospitality; and top with evenings full of entertainment sprinkled with a western tang. It wouldn't be quite accurate to say: "then bake at 96 degrees," for after all the temperature was really a pleasant 71 plus and minus 25 degrees.

One thing sure, this was no slow oven. From the time that Ropemin Filby's Brandin' and Sortin' committee rode 'em down until Gentleman Gerry Arnold let 'em loose again on Friday noon, those as carried the AWWA brand were stampeded constantly and on schedule. Technical sessions two at a time from 9:30 till 5:00; committee sessions from earlier morning till midnight; bull sessions always all over the place. And every evening something special: Sunday saw 750 old friends old friending. Monday gave many more the opportunity to pay tribute to new Honorary Members Norman Howard, Howard Morse, and Tom Veatch; to Diven Medalist Ernest Whitlock; to Goodell Prizewinners Joe Sanchis and John Merrell; to 25 new Fuller Awardees; and to a full complement of officers

(Continued on page 2)

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1952 CONFERENCE STATISTICS

(Story on p. 1, P&R)

Kansas City Registration by Days

Day	Men	Ladies	Total
Sunday, May 4	572	181	753
Monday, May 5	558	123	681
Tuesday, May 6	112	15	127
Wednesday, May 7	67	—	67
Thursday, May 8	49	—	49
TOTALS	**1,600**	**386**	**1,986**

Geographical Distribution of Registrants

UNITED STATES & TERRITORIES

Alabama	31
Arizona	10
Arkansas	16
California	87
Colorado	35
Connecticut	11
Delaware	5
Dist. Columbia	16
Florida	30
Georgia	26
Hawaii	2
Illinois	177
Indiana	44
Iowa	78
Kansas	127
Kentucky	18
Louisiana	35
Maine	2
Maryland	15
Massachusetts	18
Michigan	41
Minnesota	37
Mississippi	6
Missouri	270
Montana	3
Nebraska	28
New Jersey	96
New York	147
North Carolina	19
North Dakota	5
Ohio	84
Oklahoma	52
Oregon	5
Pennsylvania	133
Puerto Rico	1
Rhode Island	21
South Carolina	15
South Dakota	10
Tennessee	42
Texas	71
Utah	2
Vermont	1
Virginia	16
Washington	5
West Virginia	9
Wisconsin	50

CANADA, CUBA & FOREIGN

Canada	26
Cuba	3
Dominican Republic	2
Japan	2
TOTAL	**1,986**

Comparative Registration Totals—1943–1952

Year	Place	Men	Ladies	Total
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967
1948	Atlantic City	1,348	356	1,704
1947	San Francisco	1,115	431	1,546
1946	St. Louis	1,303	214	1,517
1944	Milwaukee	1,185	171	1,356
1943	Cleveland	973	158	1,131

Win, Place & Show in Section Awards

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Cuban	**80.0%**	**Kansas**	**49.95**	**California**	**989**
W.Va.	58.5%	Indiana	36.42	New York	699
Ala.-Miss.	57.7%	Florida	32.30	Southwest	670

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(Continued from page 2)

who played hosts at the function. Whoopee Tuesday was just that, with western costume, western dancing, western entertainment, and western gambling to make a real "Cowtown Jamboree." Wednesday brought a special performance of "The River" to KC—this time a dry and quiet one. And Thursday found just short of a thousand gathered in the spacious arena of the Municipal Auditorium to surround a steak; to cheer the Kansas, Cuban, and California Sections for winning the Hill Cup, the Henshaw Cup, and the Old Oaken Bucket; to salute Abel Wolman as first recipient of the Harry E. Jordan Achievement Award; to say "Thanks" and "Well done" to Bert Berry for a year without peer; to install Charlie Capen in the high chair for the year to come; and, finally, to dance.

Those, though, were only the high spots of a wakeful weekful of activity. Monday, for instance, also found hometown pro Mel Hatcher carding a neat 85 to win the annual golf tournament for a third time, thus retiring the cup, while Earl Hodges of Sparling Meter and Larry Seton of Lock Joint Pipe one-twoed the open competition with scores of 77 and 80, respectably! Tuesday and Wednesday saw men of the Missouri, Kansas, New York and New Jersey, and California Sections eating their way through special luncheon meetings. Thursday, a record 285 manufacturers got together behind steaks to listen to Dr. John H. Furbay. Every day, twice a day, large contingents of registrants enbussed for inspection trips to the water treatment plants of one or the other of the Kansas City's. On the one hand, there was a rodeo in town; on the other, there was much of the ruin left by last year's flood to be viewed. Never a dull moment, and certainly never a moment when one of the local hosts, functioning under the general direction of Tom Veatch, Mel Hatcher and Bob Millar, wasn't ready with aid, encouragement, or entertainment. All this and a record ladies' program too, taking water wives from a luncheon at the top of the Hotel President to "Orpheus in the Underworld" at the University of Kansas City under the guidance of Mrs. Mel Hatcher.

A full beak and a full week—that was KC '52. And now on to Grand Rapids, May 10–15, 1953!

Before getting on the furniture van, though, we ought to pay our last respects to Kansas City Kitty. Kitty was a plump and pretty 65 when last we fondled her. Then, along came Bert Berry and Bucks Blomquist and hit her right on the nose. Almost unbelievable, but both of them picked 1,986 and, thus, had to settle for a practically paltry $32.50 each. We're speaking, of course, of the Board of Directors' annual convention attendance pool—one dollar and one guess per person per January, winner take all. Inasmuch as the winners are all but required to provide a careful accounting of the extravagances into which their good fortune will lead them, we'll leave Kitty's future to their rather than our imagination.

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A clasp in a KC dive involving some unidentified AWWA male and a gal named Jehanne Desmond sounded like the best convention copy of all, until, watered down, it turned out to be a gold tie clasp lost by the unidentified male at a quite respectable cocktail lounge named Eddy's located at 1300 Baltimore and now being held for him by Miss Desmond, whom please write.

New Jersey just can't seem to hold its water these days. A couple of months ago at Jamesburg it was two-mile-square Lake Manalapan that ran away when two youngsters opened one of the floodgates in an effort to retrieve a drifting boat. And just the other day, two-mile-long Lake Lefferts at Matawan disappeared down the drain to Raritan Bay despite the heroic efforts of taxpayers who sought to protect their investment in lakefront property by throwing a sandbag thumb in the dike. No child's play this, the floodgates were opened to release an excess of water that threatened expensive lawns around the lake. But one of the gates refused to close when the lake was back to normal level. An emergency call for a diver to grapple with the gate brought an early morning influx of movie and television crews as well, all primed for underwater heroics. Only trouble

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was, dawn disclosed disaster—no lake at all and scarcely enough dampness to make the mechanic who repaired the broken valve gear wear rubbers.

Fortunately none of the Great Lakes comes even close to New Jersey.

The hydraulic calculator that was announced in the December 1951 JOURNAL (p. 12 P&R) has now been produced and is ready for immediate delivery. In circular slide-rule form, the 6-in. plastic calculator can be used to determine head loss, flow, velocity, pipe size, or the Hardy-Cross factor $1.85 \frac{h}{Q}$. Calibrations are based on the Hazen-Williams formula, with discharge given in mgd or gpm. A range of C values from 60 to 100 for various sizes of pipe, ranging from 4 to 72 in., is given. The price is $6.00, postpaid, from Robert E. Martin, 210 Heyburn Bldg., Louisville, Ky.

A Conference of Municipal Authorities—the tenth of an annual series sponsored by the Pennsylvania Municipal Authorities Assn.—will be held at the Abraham Lincoln Hotel, Reading, Pa., on Sept. 15–17, 1952. Details may be obtained from the association at 103 Sparks Bldg., State College, Pa.

(Continued on page 10)

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(Continued from page 8)

Putting on the pressure, like everything else these days, has come to be more and more a matter of water supply. When some of the East German Communist youth became overdemonstrative in Berlin recently, police applied their pressure through a fire hose. And closer home, when some of the prisoners in the New Jersey state prison at Trenton became obstreperous, it was water pressure again that was applied to bring them back in line—first by pumping tons of water into the affected prison wing to flood out some; then by withholding water from those who failed to respond to overtreatment. But those are examples of only negative pressure. Positively, too, out in Centralia, Ill., for instance, the force required to bring $500,000,000 worth of oil to the surface is going to be water pressure, supplied by a special water system big enough to supply a city of 200,000.

To moil, to foil, to bring up oil, just turn it on, or even off.

Elliott E. Brainard, formerly vice-president in charge of sales of the Lock Joint Pipe Co., has joined the American Pipe & Construction Co. in the same capacity.

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C. Laurence Warwick, executive secretary of the American Society for Testing Materials, died suddenly on April 23, shortly after presiding at a society dinner. He was 63.

A leader in the standardization field, he had been active in ASTM since 1909, and was its administrative head since 1919, when he was appointed secretary-treasurer. During World War II he was responsible for considerable saving of critical materials while head of the Specifications Branch of the Conservation Div., and, later, of the Materials Div., for the War Production Board.

George F. Catlett, sanitary engineer with the Stream Sanitation Committee of the North Carolina Board of Health, died at his home in Raleigh on March 22.

His connection with the board dated back to 1920, when he became principal assistant engineer in the Div. of Sanitary Engineering, in charge of water supply, sewage, and industrial waste treatment. In 1932 he resigned to accept posts with the Public Health Service and the Florida Board of Health, returning to North Carolina in 1946.

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Crying in one's beer is going to be more a matter of necessity than effect any day now. The just-add-water boys have finally gone and undone it—they've blasted the barrel, put the kibosh on the keg, torn out the tap—they've dehydrated beer. Culprits are two British scientists who found that, by freezing beer until approximately 75 per cent of its volume was ice, they could remove the water, frozen, and leave a concentrate which contained "the hops, the tang, the zip, the alcoholic kick, and even the foam" of the original product. Just add water, they say, and there's your beer again. Just what we say isn't printable.

Primary purpose of the dastardly deed places it in the category of war atrocity, for it was at the behest of the British War Office that the two scientists began research on a method of making beer for the far-flung troops of Great Britain more economically transportable. And what scientists, we wonder, are even now at work on the problem of dehydrating Britain's soldiers to make them, too, more easily moved? Too bad, really, that the beerdriers succeeded first, or we might have worked out an economical system for transporting dehydrated men to whole beer. What jolly fun, too, rehydrating, don't you know?

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Short course proves long on useful facts as M. Starr Nichols (left) of the University of Wisconsin offers pointers on testing water samples to Ivan Sorenson of Superior, George MacDonald of Neenah, William J. Collings of Onalaska, and Louis Fitch of South Milwaukee. School was held April 21–24 at the university's Hydraulics Lab. in Madison.

Frederick Ohrt has resigned the post he has held for over 25 years as manager and chief engineer of the Honolulu Board of Water Supply. A Honolulu court recently accorded him a lifetime appointment as one of the three trustees of the James Campbell estate.

Diamond Alkali Co. is planning to increase chlorine production at its plant in Houston, Tex., by 10 per cent. Originally this additional capacity was planned as part of the company's expansion program at the Painesville, Ohio, unit. A halt has been called to construction at the latter plant, and the program will be reexamined. Meanwhile there appears no reason for water works consumers of chlorine to be elated; the additional capacity is earmarked for the manufacture of perchlorethylene, a solvent and cleaner.

A pipe clamp providing a cushioned seal for steel, cast-iron and asbestos-cement pipe, even if damaged or out-of-round, is being offered by R. H. Baker & Co. Known as the Baker CirclSeal, the clamp may, according to the makers, be installed in wet ditches without draining or filling the line.

(*Continued on page 18*)


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(Continued from page 16)

Bombs awash is the order now in Canada, where they've already gone the H-bomb more than one better with a missile of H_2O. It is a real bomb, too, though, undoubtedly because heavy water isn't required, it weighs only approximately 30 lb—3½ gal of water in a specially made paper bag. Not for bigger and wetter fun for the kiddies either, these bombs are used by the Ontario Department of Lands and Forests for the very serious business of combating forest fires, being dropped on the burning areas from planes flying at altitudes near 300 ft. Not only by wetting the target area, but by adding water vapor to the air in the vicinity, the big splash technique has been found effective in retarding the advance of fires. Whatever the distribution system, water sure manages to get around—drop by drop.

Speaking of getting around, MIT's who became WHO's who last month, when Rolf Eliassen, professor of sanitary engineering and director of the Sedgwick Laboratories at the Massachusetts Inst. of Technology, was designated by the Dept. of State as the engineer member of the U.S. delegation to the fifth assembly of the World Health Organization. Granted a leave of absence from MIT, Eliassen had an opportunity to work with delegations from more than 60 countries at the May meeting in Geneva.

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What to do with ex-presidents—the dilemma posed by an election year and requiring, according to some observers, no less than a constitutional amendment for its solution—poses no problem for AWWA's finest. When foresighted A. E. Berry stepped down as AWWA head at the Thursday evening banquet on May 8 at Kansas City (this issue, P&R p. 4), he had laid careful plans against joining the ranks of unemployed officialdom. The timing was perfect: the very next night, in Vancouver, B.C., the Engineering Institute of Canada installed him as a vice-president. So, if we may make a suggestion, shed no tears for our departing Prexy, rather Veep.

A record-smashing registration of 604 proved that Texas does things in a big way, and got the 34th annual Short School of the Texas Water & Sewage Works Assn. off to a good start on March 9. In addition to the technical sessions and regional association meetings, awards were presented to utilities in the state for such accomplishments as having the highest proportion of population connected to the public water supply system, the best water plant laboratory, the most attractive-looking treatment plant, and similar virtues.

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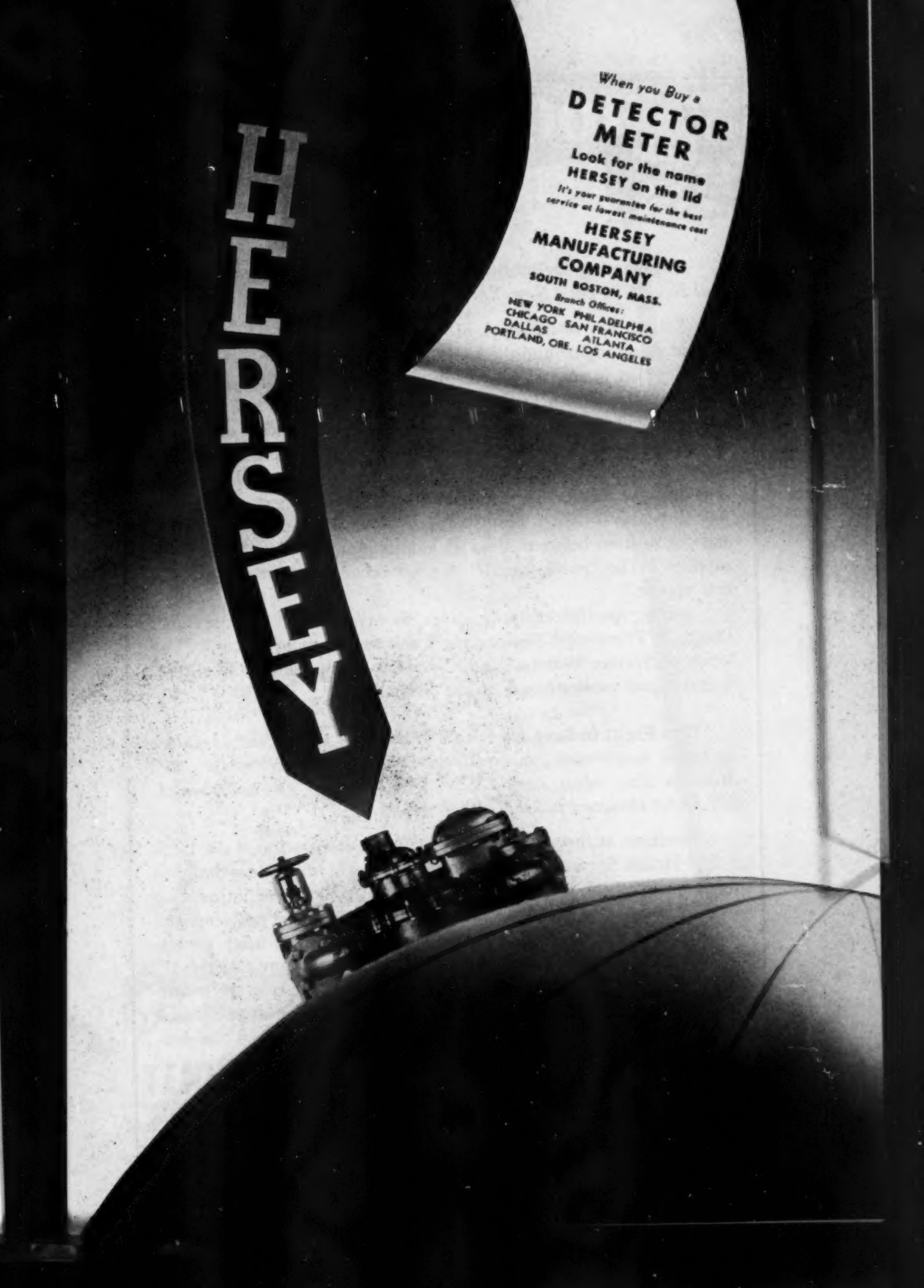
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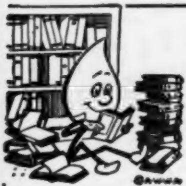


The Reading Meter

Engineering in Public Health. *Harold E. Babbitt. McGraw-Hill Book Co., Inc., New York (1952) 582 pp.; $8.00*

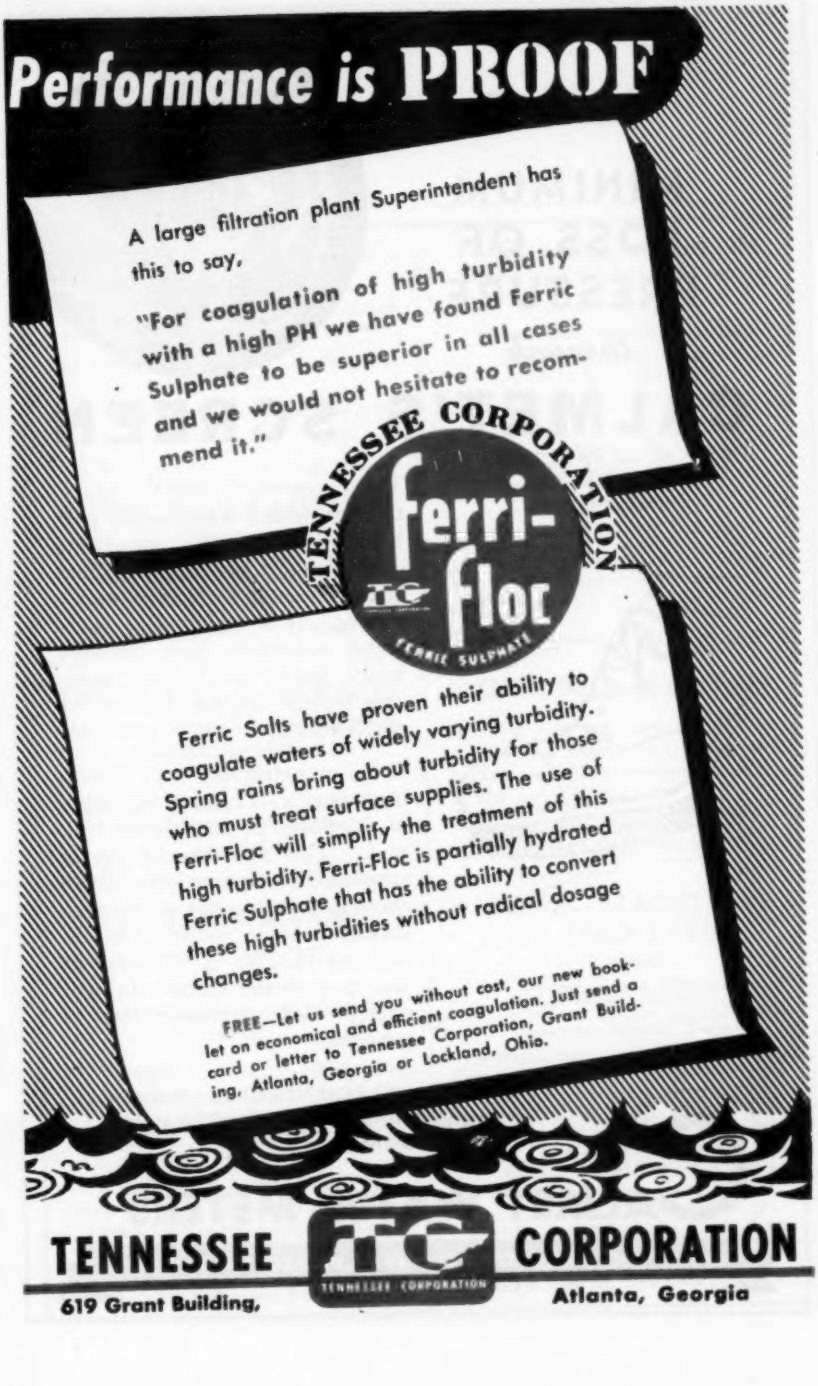
This survey of the work of the engineer in public health covers a great many topics, and the water supplier will find little on his own specialty that is new or enlightening. The sense of perspective that the book affords of a broad campaign against disease and ill health, however, will help the individual understand the relation of his particular efforts to the whole. In this respect it is interesting to note that in his general or philosophical introductory chapters, Dr. Babbitt considers the lengthening life-span (in 1900, life expectancy at birth was 49 years; it is now near 70 and by 2300 A.D. may well be 100) and the relation between areas of industrial activity and good water supplies. The "public health" is a far broader term than might at first appear.

Among specific chapter headings, those on "Water and the Public Health," "Plumbing," "Swimming Pools and Bathing Places," "Pollution of Surface Waters," and "Sanitary Engineering in Disasters" would appeal most strongly to the water worker.

The Fight to Save America's Waters: *A Mark Trail adventure in public health and conservation. Post-Hall Syndicate, Inc., 295 Madison Ave., New York 17, N. Y. (1952) 16 pp., paperbound; $19.50 per thousand in 5,000 lots*

Produced at the suggestion and with the cooperation of the U. S. Public Health Service, this comic-style booklet in full color is designed to do an excellent job, through quantity distribution, of introducing the unsophisticated reader to the urgency of pollutional problems and the need for treatment works to solve them. Unfortunately the approach, being heavily weighted on the "preserve the forest primeval" theme, might appear less immediate or realistic to the average metropolitan dweller than a less dramatic emphasis upon the economic and industrial effects. These last are mentioned, however, and the publisher may be excused for not trying to leave the sugar coating of adventure and color off his didactic pill.

(Continued on page 74)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Membership Changes

NEW MEMBERS

Applications received April 1 to April 30, 1952

Adkins, Doyle, *see* Frankfort (Ind.) Water Works

Agee, James L., Jr. San. Engr., State Board of Health, 1400 S.W. 5th St., Portland, Ore. (Apr. '52) *MP*

Andersen, James Charles, Dist. San. Engr., State Dept. of Health, Div. of San. Eng., Munic. Bldg., Aberdeen, S.D. (Jan. '52) *P*

Baker, Robert S., Dist. Mgr., Indiana Gas & Water Co., Inc., Franklin, Ind. (Apr. '52) *MP*

Banchon Maruri, Alberto, Chemist, Purif. Plant, Water Dept., Guayaquil, Ecuador (Apr. '52) *PR*

Barman, John E., Engr., Missouri Inspection Bureau, St. Louis, Mo. (Apr. '52)

Barnard, Niles Hutton, Prof. & Chairman, Dept. of Mech. Eng., Univ. of Nebraska, 203 Richards Lab., Lincoln 8, Neb. (Apr. '52) *M*

Beebe, Richard L., Graduate Student, Univ. of Wisconsin, Bascom Hall, Madison 6, Wis. (Jr. M. Apr. '52) *MP*

Bethany Munic. Light & Water Plants, Woodie Scott, Supt., Water Works, Bethany, Mo. (Mun. Sv. Sub. Apr. '52) *MP*

Blocker, Leroy Vern, Supt. of Utilities, 450 Commercial Ave., Superior, Neb. (Apr. '52) *MPR*

Blood, Arthur E., Mgr., The Terre Haute Water Works Corp., 119 S. 7th St., Terre Haute, Ind. (Apr. '52) *M*

Bunnell, Frank Royce, Sr. Asst. Engr., Greater Vancouver Water Dist., 1303 Sun Bldg., Vancouver, B.C. (Apr. '52)

Butler, Eugene W., E. W. Butler & Assocs., 2023 Railway Exchange Bldg., 611 Olive St., St. Louis 1, Mo. (Apr. '52) *P*

Cessna, H. W., Sales Repr., Mueller Co., 2935 Pierpont Ave., Columbus, Ga. (Apr. '52) *M*

Clark, Raymond W., 506 W. Marshall St., Tulsa 6, Okla. (Apr. '52) *P*

Coldewey, George, Mng. Supt., Water, Light & Power Dept., City Hall, Jacksonville, Ill. (Apr. '52) *MR*

Collins, Joe P., Pres. & Gen. Mgr., Utility Supply Co., 5828 Harvey Wilson Dr., Houston, Tex. (Apr. '52) *M*

Columbia Water Co., John S. Shute, Vice-Pres. & Mgr., 518 American Bank Bldg., Portland 5, Ore. (Corp. M. Jan. '52) *MPR*

Comey, David Parker, Mech. Engr., Frank H. Brigham, Gen. Eng. Contractor, 265 El Cajon Blvd., El Cajon, Calif. (Apr. '52) *R*

Container Corp. of America, J. D. Johnson, Tech. Supt., 404 E. North Water St., Chicago 11, Ill. (Corp. M. Apr. '52) *PR*

Cook, Jean N., Jr. San. Engr., Water Purif. Div., Water Safety Control Section, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Apr. '52) *MP*

Cook, W. Coburn, Lawyer, Berg Bldg., Turlock, Calif. (Apr. '52) *R*

Corominas Pepin, Rafael A., Asst. Engr., Direccion General de Acueductos, Ciudad Trujillo, Dominican Repub. (Apr. '52) *M*

Cregg, George W., Attorney, Melvin & Melvin, Merchants Bank Bldg., 214 S. Warren St., Syracuse, N.Y. (Apr. '52) *M*

Daily, Jack Frederick, Head, Civ. Eng. Dept., Lutz & May, Cons. Engrs., 819 Finance Bldg., Kansas City, Mo. (Apr. '52) *P*

del Rosario C., Enriquillo Antonio, Ingeniero Encargado de Pozos y Molinos, Direccion General de Acueductos, Ciudad Trujillo, Dominican Repub. (Apr. '52) *M*

(*Continued on page 32*)

(*Continued from page 30*)

Dodge, Eldon R., Prof. of Civil Eng., Montana State College, Bozeman, Mont. (Apr. '52) *MR*

Donahue, Paul Richard, Sales Engr., Harry T. Porter Co., 1425 Union Central Bldg., Cincinnati, Ohio (Apr. '52) *MP*

Donnelly, Leo J., Comr., North Jersey Dist. Water Supply Com., 169 E. 6th St., Clifton, N.J. (Apr. '52) *MP*

Doty, Glen Anderson, City Engr., Director of Public Utilities, Alice, Tex. (Apr. '52) *M*

Edwards, Stanley M., Salesman, Binghamton Industrial Supply, 203 State St., Binghamton, N.Y. (Apr. '52) *M*

Fague, Frank F., Gen. Foreman, Water Bureau, 1900 N. Interstate Ave., Portland 12, Ore. (Apr. '52)

Fee, John Raymond, Civ. Engr., James M. Montgomery, Cons. Engr., 15 N. Oakland Ave., Pasadena 1, Calif. (Apr. '52) *PR*

Fender, Thomas J., Asst. Supt., Water Works, City Hall, Augusta, Ga. (Apr. '52) *M*

Ferguson, Wayne, *see* Horseheads (N.Y.)

Flanigan, John G., Member, North Jersey Dist. Water Supply Com., 26 Journal Square, Jersey City, N.J. (Apr. '52)

Frankfort Water Works, Doyle Adkins, Supt., Frankfort, Ind. (Corp. M. Apr. '52)

Frederiksen, Earl, Safety Engr., Supervisor of Health & Safety, Metropolitan Utilities Dist., 18th & Harney St., Omaha, Neb. (Apr. '52) *M*

Fry, James R., Supt., Water Dept., Burlington, Kan. (Apr. '52) *MP*

Fuchs, Albert J., Supt. of Water Works, Karnes City, Tex. (Apr. '52) *M*

Gates, Albert James, Chief Engr., Southwestern Norcam, 6617 Snider Plaza, Dallas 5, Tex. (Apr. '52)

Geyer, Glenn M., Supt., Public Utilities Com., Box 145, New Ulm, Minn. (Apr. '52) *M*

Gilbert, George E., Command San. Engr., Headquarters Air Defense Command, U.S.A.F., Colorado Springs, Colo. (Apr. '52) *MP*

Graham, D. W., Dist. Sales Mgr., Pennsylvania Salt Mfg. Co., 1828 Carew Tower, Cincinnati, Ohio (Apr. '52)

Harbes, John G., *see* Plainview Water Dist. (N.Y.)

Harford, G. P., Munic. Engr., Dist. of Coquitlam, 1111 Brunette St., New Westminster, B.C. (Apr. '52)

Hayob, Charles Robert, Chemist, Munic. Utilities, Marshall, Mo. (Apr. '52) *P*

Herup, William C., Director, Marin Munic. Water Dist., San Rafael, Calif. (Apr. '52) *MR*

Hesse, Henry A., Export Mgr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y. (Apr. '52)

Highleyman, Frank, Black & Veatch, 4706 Broadway, Kansas City 2, Mo. (Apr. '52)

Holland, Max, Asst. City Mgr.-Supt. of Utilities, Camden, S.C. (Apr. '52) *M*

Hordes, Herbert J., Civ. Engr., Pate & Hirn, 532 Michigan Bldg., Detroit, Mich. (Jr. M. Apr. '52) *MPR*

Horrell, Dewey, Gen. Mgr., Water Utility, West Frankfort, Ill. (Apr. '52) *M*

Horseheads, Village of, Wayne Ferguson, Water Supt., 202 S. Main St., Horseheads, N.Y. (Corp. M. Apr. '52)

Horton, Pleasant Earl, Mgr., Russellville Water Co., Inc., Box 82, Russellville, Ark. (Apr. '52) *MP*

Hosford, John, Exec. Secy. & Treas., National Assn. of Water Conditioning Equipment Mfrs., 39 S. LaSalle St., Chicago 3, Ill. (Apr. '52) *PR*

Humphries, Marguerite (Miss), Water Supt. & Clerk-Treas., City Hall, Alexandria, Ind. (Apr. '52) *M*

Johnson, George Harold, Asst. Supt., Distr. Div., Water, Gas & Sewage Disposal Dept., Duluth, Minn. (Apr. '52) *M*

Johnson, J. D., *see* Container Corp. of America

Johnson, Lawrence J., *see* Rockaway (Ore.) Water System

Johnson, Mary E. (Miss), Owner & Supt., Wood Water Co., Hampton, Tenn. (Apr. '52) *M*

Kaneshige, Harry Masato, Graduate Student, Univ. of Wisconsin, 22 N. Franklin St., Madison 3, Wis. (Jr. M. Apr. '52) *P*

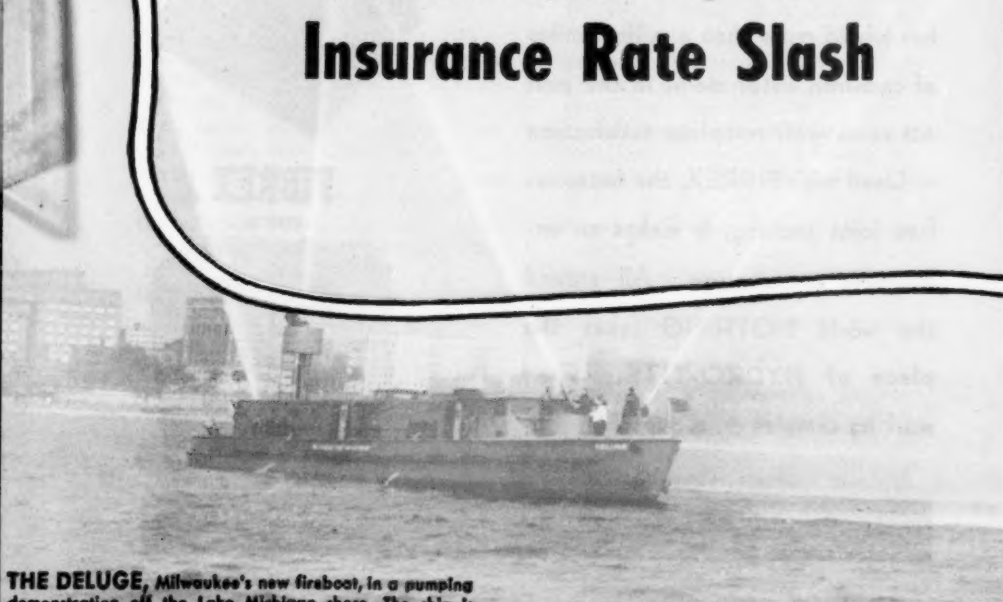
Kessler, Kenneth Oneal, Gen. Mgr., The Kessler Co., Fremont, Ohio (Apr. '52)

(*Continued on page 36*)

WATER

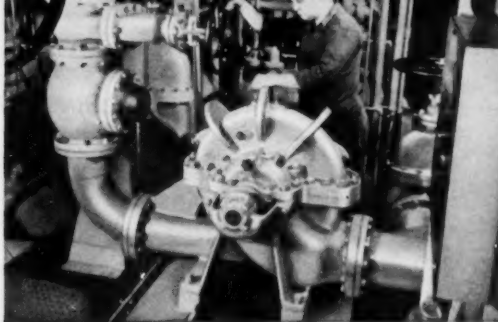
for Milwaukee's fire fighters!

Allis-Chalmers Pumps Help Secure $900,000 Insurance Rate Slash



THE DELUGE, Milwaukee's new fireboat, in a pumping demonstration off the Lake Michigan shore. The ship is 96 ft 7 in. overall and built low to clear unraised river bridges.

BELOW DECKS, four Allis-Chalmers pumps supply the 4 water-throwing monitors and 14 three-inch discharge ports. Single stage construction reduces space and simplifies maintenance. Four Nordberg 375-hp, 600-rpm supercharged diesel engines supply power for propulsion and pumping.



MAIN PUMPS are each rated 3000 gpm at 150 psi, but have exceeded this by 11%. They are Type S, 10 by 8-in., bronze fitted, double suction centrifugal pumps. In 1951 the *Deluge* responded to 49 alarms, spent 72 hr and 23 min on duty at alarms, and pumped 1,145,125 gallons of river water.

A $900,000 ANNUAL PREMIUM SAVING results from the recent reduction in Milwaukee fire insurance rates. One of the very few cities so benefited, Milwaukee can be proud of the trained personnel and complete equipment in its excellent fire department.

Over 90% of the city's municipal pumps are Allis-Chalmers. And A-C pumps are used exclusively on the new fireboat *Deluge* — an important factor in Milwaukee's Class I Fire Department rating and Class II Fire Insurance rating. No city ranks higher, and few as high, in these ratings by the National Board of Fire Underwriters.

The *Deluge* — with a rated capacity of 12,000 gpm and proven capability of 13,835 gpm — is the largest capacity fireboat west of New York City. A fresh water dreadnaught with reinforced welded steel hull, it doubles as an icebreaker in keeping the Milwaukee, Menomonee, Kinnickinnic rivers and Burnham canal navigable. And, in addition to fighting fires, its pumps have proven valuable in aiding snow disposal in the rivers.

The *Deluge's* first "work call" was to fight from its decks a waterfront fire in a waste paper warehouse. More often it works as a floating booster station, pumping river water into a dry pipeline network in the commercial area. This separate system is put into action at conflagrations to supplement the city water supply.

When *your city* plans expansion or modernization, do as Milwaukee and other leading cities are doing — take advantage of Allis-Chalmers experience in municipal pumping equipment. For detailed information contact your nearest Allis-Chalmers district office or write to Allis-Chalmers, Milwaukee 1, Wis.

A-3746

SEND FOR THESE BULLETINS:

Centrifugal Fire Pumps, 08B6336A . . . Type S Centrifugal Pumps, 08B6146A . . . Pumps for Every Industry, 52B6059H . . . Handbook for Care of Centrifugal Pumps, 08X6256A.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

Builders of the World's Widest Range of Public Works Equipment

(*Continued from page 34*)

Kestner, Joseph A., Jr., Sr. Engr., Barker & Wheeler, 36 State St., Albany 7, N.Y. (Apr. '52) *PR*

Killmer, Edward Peter, Water Supt., Osseo, Minn. (Apr. '52)

Kitchen, Howard V., Eastern Water Works Repr., Dresser Mfg. Co., 122 E. 42nd St., New York, N.Y. (Apr. '52)

Kuranz, Joseph Hughes, Engr., Water Utility, 132 North St., Waukesha, Wis. (Jan. '52) *M*

Laherran, Joseph, Supt., Water Dept., 509 Benton St., Santa Clara, Calif. (Apr. '52)

Lane, Bruce S., *see* Upjohn Co.

Lange, J. Andrew, Sales Engr., Schultz-Forster Assocs., City Bank Bldg., Syracuse, N.Y. (Apr. '52) *P*

Leskela, Harry B., Supt., Aloha-Huber Water Dist., Aloha, Ore. (Apr. '52) *M*

Longson, C. L., *see* Menlo Park (Calif.)

Love, James L., Supt., Water & Sewage, Box 208, Lafayette, La. (Apr. '52) *MP*

Luce, John, Supt., Fort Smith Water Co., 504 N. 39th St., Fort Smith, Ark. (Apr. '52) *MPR*

Luft, Fred, Owner & Mgr., Luft Constr. Co., 111½ W. 5th Ave., Pine Bluff, Ark. (Apr. '52) *M*

Lutz, Hobart F., Lutz & May, Cons. Engrs., 819 Finance Bldg., Kansas City, Mo. (Apr. '52) *M*

Marold, Frank, Field Repr., Warren Foundry & Pipe Corp., 55 Liberty St., New York, N.Y. (Apr. '52) *M*

Marr, George J., City Engr., Director Public Works, Burlingame, Calif. (Apr. '52) *M*

Marron, Hal E., Asst. Civ. Engr., Water Dept., 400 Munic. Utilities Bldg., Long Beach 2, Calif. (Apr. '52) *MR*

Martin, Benjamin A., City Clerk & Waterworks Supt., Bowdon, Ga. (Apr. '52) *MP*

McGaw, Samuel H., Asst. Supt., Water & Sewer Dept., Maple Shade, N.J. (Apr. '52) *MP*

McKinney, Glenn, Supt. of Water, Water Works, Remington, Ind. (Apr. '52)

McMurtrie, Mary E., (Miss), *see* Tiltonsville (Ohio) Board of Public Affairs

Menendez Saiz, Modesto, Civ. Engr., Comision de Fomento Nacional, 1003 Calle 23, Vedado, Havana, Cuba (Apr. '52)

Menlo Park, City of, C. L. Longson, City Mgr., City Hall, Menlo Park, Calif. (Mun. Sv. Sub. Apr. '52) *M*

Merchant, Ralston W., Sales Engr., Wallace & Tiernan Co., Inc., 418 Flannery Bldg., Pittsburgh 13, Pa. (Apr. '52)

Metz, Robert J., Salesman, Homelite Corp., 1546 William St., Buffalo 6, N.Y. (Apr. '52)

Miller, George Robertson, Gen. Mgr., Board of Public Works, Beatrice, Neb. (Apr. '52) *M*

Morgan, Donald C., Dist. Mgr., Rockwell Mfg. Co., 1001 Peoples Gas Bldg., Chicago 3, Ill. (Apr. '52)

Mubayi, B. N., Water Supply Engr., E. P. Railway Headquarters Office, The Mall, Delhi, India (Apr. '52)

Nelson, Lind B., Supt. of Waterworks, Sewerage, & Street Lighting, City Hall, Galveston, Tex. (Apr. '52) *MPR*

Nesselson, Eugene J., Research Asst. in Civ. Eng., Hydr. & San. Eng. Labs., Univ. of Wisconsin, Madison 6, Wis. (Jr. M. Apr. '52) *P*

Noble, John William, Jr., Vice-Pres. & Treas., Soft Water Service Inc., 1222 Greenleaf St., Allentown, Pa. (Apr. '52) *MP*

Norrell, Robert G., Sr., Supt., Water & Sewers, 1336 Raburn Ave., Guntersville, Ala. (Apr. '52) *MP*

Odom, Joseph Francis, Supt., Filtration Plant, Savannah, Ga. (Apr. '52) *M*

Olsen, Harvey H., Relief Operator, Filtration Plant, R.F.D. 1, Pasco, Wash. (Apr. '52) *MP*

Owen, Milo L., Supt. of Water Works, Sunbury, Ohio (Apr. '52)

Owen, William Hunter, Prin. San. Engr., State Dept. of Public Health, 420—6th Ave., North Nashville, Tenn. (Apr. '52) *MP*

Palen, Clifford Thomas, Water Engr. & Chemist, Shell Oil Co., Box 728, Wilmington, Calif. (Jan. '52) *P*

Patrick, Kenneth Ernest, Engr., Greater Vancouver Water Dist., 1303 Sun Bldg., Vancouver, B.C. (Apr. '52)

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Patton, Fred J., Sales Repr., Badger Meter Mfg. Co., Box 991, Springfield, Ill. (Apr. '52) *M*

Paul, Leslie, Supervising Mech. & Elec. Engr., East Bay Munic. Utility Dist., 512—16th St., Oakland 12, Calif. (Apr. '52)

Perez Y Franco, Diosdado, Civ. Engr., J. Z. Horter Co., Espada 7, Apt. 302, Havana, Cuba (Apr. '52) *R*

Petrykowski, Leonard J., Asst. Civ. Engr., Water Supply, 735 Randolph St., Detroit 26, Mich. (Apr. '52) *MR*

Plainview Water Dist., John G. Harbes, Foreman, Old Country Rd., R.F.D. 1, Hicksville, N.Y. (Mun. Sv. Sub. Apr. '52) *M*

Poirier, Cuthbert, Town Mgr. of St. Michel, Metropolitan Com. Montreal, 6955 Sagard St., Montreal 35, Que. (Apr. '52)

Purcell, Paul, Supt., Water Dept., Village Hall, Barrington, Ill. (Apr. '52) *M*

Rehm, Leo F., Civ. Engr., Consoer, Townsend & Assocs., 351 E. Ohio St., Chicago 11, Ill. (Apr. '52) *PR*

Reitzes, Joseph M., *see* U.S. Rubber Co.

Remsburg, William Norris, Engr., Joe J. Rady, 811 Insurance Bldg., Fort Worth, Tex. (Apr. '52) *MPR*

Ridewood, Donald Alfred, Jr. Chem. Engr., Water Dept., Transportation Bldg., Ottawa, Ont. (Apr. '52)

Rockaway Water System, Lawrence J. Johnson, Supt., Box 156, Rockaway, Ore. (Mun. Sv. Sub. Apr. '52) *M*

Roller, John Anthony, San. Engr., Water Div., Dept. of Public Utilities, 402 City Hall, Tacoma, Wash. (Apr. '52) *MR*

Santandrea, Anthony, Sales Repr., Warren Foundry & Pipe Corp., 55 Liberty St., New York, N.Y. (Apr. '52)

Schultz, John F., Supt., Munic. Light & Water Plant, Mountain Lake, Minn. (Apr. '52) *MP*

Scott, Woodie, *see* Bethany (Mo.) Munic. Light & Water Plants

Shotwell, Raymond Lee, Field Service Engr., The Permutit Co., Household Dept., Birmingham, N.J. (Apr. '52) *P*

Shute, John S., *see* Columbia Water Co. (Ore.)

Sini, Anthony, Water Main Contractor & Owner, North Shore Water Co., Rocky Point, N.Y. (Apr. '52) *MP*

Sloan, Lloyd, Water Supt., Katy, Tex. (Apr. '52) *M*

Smith, Julian Polk Stuart, Jr., Sales Engr., Neptune Meter Co., 2014 Grove Ave., Richmond, Va. (Apr. '52)

Solis Sotomayor, Hector E., Asst. Chief, Planta Purificadora, Departamento de Agua Potable, Box 3544, Guayaquil, Ecuador (Apr. '52) *MPR*

Sparboe, John H., Contractor, John Sparboe & Son, 1101 Grand Ave., Billings, Mont. (Apr. '52)

Taylor, Floyd E., Chief Engr., Water Works, Wheeler & Cincinnati Aves., Anderson, Ind. (Apr. '52) *M*

Teeson, Robert F., Supt., Columbia Water Co., Washougal, Wash. (Jan. '52) *MPR*

Thompson, John Franklin, Plant Operator, Batesville Water Co., Sidney & Porter St., Batesville, Ark. (Apr. '52) *MP*

Tiltonsville Board of Public Affairs, Miss Mary E. McMurtrie, Clerk, Box 498a, Tiltonsville, Ohio (Mun. Sv. Sub. Apr. '52) *MP*

Tredgett, Roy G., Project Engr., Proctor, Redfern & Laughlin, 11 Jordan St., Toronto, Ont. (Apr. '52)

U.S. Rubber Co., Joseph M. Reitzes, Sr. Engr., Box 871, Joliet, Ill. (Corp. M. Apr. '52) *MPR*

Upjohn Co., The, Bruce S. Lane, Chem. Eng. Dept. Head, Kalamazoo, Mich. (Corp. M. Apr. '52) *PR*

Valdes, Manuel, Engr. in Charge of Operation & Maint., Direccion General de Acueductos, Ciudad Trujillo, Dominican Repub. (Apr. '52) *M*

von Bennewitz, Jorge, Director de La Escuela de Ingenieria, Universidad de Chile, Santiago, Chile (Apr. '52) *MPR*

Vopelak, Edwin L., Asst. Hydr. Engr., Public Service Com., 233 Broadway, New York, N.Y. (Apr. '52) *MR*

Watlington, Hereward T., Watlington Waterworks, Devonshire, Bermuda (Apr. '52)

Weir, Allan A., Branch Mgr., Paddock Eng. Co., 4112 Commerce Ave., Fairfield, Ala. (Apr. '52) *P*

(*Continued on page 40*)

(*Continued from page 38*)

Weir, Francis S., Regional Water Consultant, U.S. Public Health Service, 201 Norman Bldg., Dallas 2, Tex. (Apr. '52) *MPR*

Weis, Frank G., Asst. Chief Engr. & Supt., Water Dept., 4th Floor City Hall, Kansas City, Mo. (Apr. '52) *MPR*

Westphal, Lester N., Supt. of Water & Sewer, 9412 S. Kedzie St., Evergreen Park 42, Ill. (Apr. '52) *M*

Williamson, Orril I., Supt., Water Works, Anderson, Ind. (Apr. '52) *M*

Woods, William J., Eastern Sales Mgr., Alabama Pipe Co., 350—5th Ave., New York 1, N.Y. (Apr. '52)

Wulf, R. J., Mayor, Box 278, Yamhill, Ore. (Apr. '52) *P*

REINSTATEMENTS

Amick, Y. L., Supt., Water Plant, West Columbia, S.C. (Jan. '51)

Asay, Ray E., 225 S. Linden St., Westmont, Ill. (Apr. '47)

Clamon, Calvin, Research Div., The Permutit Co., Birmingham, N.J. (Jan. '49)

Clark, Joseph R., E. I. du Pont de Nemours & Co., Belle Works, Tech. Section, Charleston, W. Va. (Apr. '44)

Fry, James H., Chief Chemist, Filtration Plant, R.R. 1, Lebanon Rd., Nashville, Tenn. (July '34)

Hinton, L. E., Service & Sales Repr., 1120 Scott St., Little Rock, Ark. (Apr. '43)

Hurdle, Thomas W., Partner, R. T. Hurdle & Son, Box 914, Billings, Mont. (Apr. '48)

Reddic, Carroll A., Jr., Box 892, Augusta, Ga. (July '46)

Valenzuela R., Juan, Director de Aguas, Direccion de Aguas, Chihuahua, Mexico (July '40)

Williams, Fred, 270 Huxley Ave., S., Hamilton, Ont. (Apr. '46)

LOSSES

Deaths

Ashley, Fred M., Comr. of Public Works, City Hall, Fresno 1, Calif. (Jan. '42)

Eddy, William C., Cons. Engr., 3717 Garfield, Lincoln, Neb. (Jan. '49)

Goble, L. B., Supt., Water Dept., 3rd & Vine Sts., North Platte, Neb. (Apr. '49)

Holloway, H. F., Mgr., Midland Water Co., 10th St. & Railroad Lane, Midland, Pa. (Oct. '51) *MPR*

Massey, George B., Cons. Engr., 53 W. Jackson Blvd., Chicago 4, Ill. (July '49)

Moore, C. C., Mgr., Crane Co., 2—3rd Ave. S., Great Falls, Mont. (Jan. '41)

Resignations

Anderson, Martin E., 511 E. 8th St., Leadville, Colo. (Jan. '43) *M*

Bachelder, Herbert W., 714 W. German St., Herkimer, N.Y. (Oct. '40)

Beeville Water Works & Sewer Dept., C. R. Brock, Supt., Box 478, Beeville, Tex. (Corp. M. Jan. '47)

Bishop, Fred W., Chief Chemist, Southland Paper Mills, Inc., Box 149, Lufkin, Tex. (Jan. '50) *PR*

Corns, Richard B., Supt., City Water Works, Elkhart, Ind. (Jan. '43)

Crenshaw, Clarence W., Mgr., Oil City Welding Works, Lake Charles, La. (Apr. '51)

Dearborn Chemical Co., J. G. Surchek, Asst. Mgr. NO-OX-ID Sales, Merchandise Mart Plaza, Chicago 54, Ill. (Assoc. M. June '27)

Ferguson, J. B., Proprietor, J. B. Ferguson & Co., 312 W. Washington St., Hagerstown, Md. (Sept. '19)

Fortin, Joseph O., Etowah, N.C. (July '42)

Gaffney, L. V., Supt., Board of Public Works, Water Works, San. Sewers, Elec. Light & Power, Gaffney, S.C. (July '38) *M*

Jefferson Chemical Co., Inc., Neches Plant, L. R. Strawn, Plant Mgr., Port Neches, Tex. (Corp. M. Jan. '48)

Jones, Charles, Water Works Supt., Corp. of Richmond, Town Hall, Brighouse, B.C. (Jan. '45)

Keegan, W. F., Elec. Engr., English Elec. Co. of Canada, Ltd., St. Catharines, Ont. (July '50)

Kelly, John Claude, Supt., Oil City Welding Works, Box 701, Lake Charles, La. (Apr. '51)

Mitchell, Louis, Eng. Bldg., Room 105, Eng. & Science Campus, Thompson Rd., East Syracuse 4, N.Y. (Mar. '32)

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(*Continued from page 40*)

Morse, Daniel P., Development Engr., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Jan. '47) *MR*

Muldoon, Anthony A., Gen. Mgr., Mountain State Water Co., Mullins Bldg., Buckhannon, W. Va. (Apr. '51) *MP*

Puterbaugh, Paul M., Salesman, Knapp Supply Co., Muncie, Ind. (Oct. '51)

Riley, Edward W., Engr., Coos Bay-North Bend Water Board, 264 S. Broadway, Coos Bay, Ore. (Jan. '49)

Ross, T. T., State Health Officer, State Board of Health, Little Rock, Ark. (Jan. '47) *PR*

Rudolph, John H., Secy., Concrete Supply Co., Inc., 2020 W. Iowa St., Evansville, Ind. (July '51)

Ruehl, Edward H., Partner, R. Stuart Royer & Assocs., Cons. Engrs., 401 Virginia Bldg., Richmond 19, Va. (July '35) *PR*

Schoenewey, G. M., 4957 W. 16th St., Indianapolis, Ind. (Apr. '44)

Terre Haute Brewing Co., Inc., Oscar Baur, Pres., 440 S. 9th, Terre Haute, Ind. (Corp. M. Jan. '51) *PR*

Valve & Primer Corp., F. H. Bradford, Pres., 356 W. Huron St., Chicago 10, Ill. (Assoc. M. Apr. '48)

CHANGES IN ADDRESS

Changes received between April 5, and May 5, 1952

Alexander Chemical Corp., Alexander B. Maley, Pres., 35 E. Wacker Dr., Chicago 1, Ill. (Assoc. M. Jan. '50)

Allison, Ellis J., City Mgr., Ogden, Utah (July '44) *M*

Anderegg, James A., Sr. Asst. San. Engr., Public Health Service, 50—7th St., N.E., Atlanta 5, Ga. (Jan. '49) *PR*

Arizona Public Service Co., M. P. Goudy, Box 2591, Phoenix, Ariz. (Corp. M. Jan. '47) *MP*

Armstrong, Kenneth C., R.D. 1, Nottingham, Pa. (Dec. '24) *P*

Arrowhead Lime & Chemical Co., H. R. Brookman, Vice-Pres., Sales Div., 175 S. Alfarado St., Los Angeles 4, Calif. (Assoc. M. July '51)

Baker, Walter, *see* Garden City (Kan.)

Barney, A. C., Piping & Equipment Co., Box 1965, Wichita 12, Kan. (Apr. '50) *M*

Belleville, Laurier, Supervising Engr., National Health & Welfare, 1007 Postal Station Bldg., Montreal, Que. (Jan. '49)

Boulder Water Dept., Crawford M. Dixon, Director, Public Service, Boulder, Colo. (Corp. M. Jan. '27) *MPR*

Brown, William K., Culligan Soft Water Service Co., Windom, Minn. (Jan. '50) *PR*

Burt, Gordon L., Engr.-Mgr., Bureau of Sewage & Refuse Disposal, 5001 N. Columbia Blvd., Portland 3, Ore. (Jan. '47) *P*

Calderara, O. J., 20 Fir St., Park Forest, Ill. (Oct. '40) *MPR*

Campbell, William B., Sales Engr., A. P. Smith Mfg. Co., 620 E. Pipestone Ave., Flandreau, S.D. (Jan. '43)

Cantanese, Santi J., Sr. Civ. Engr., 1525 Gleneagle Rd., Baltimore 12, Mo. (Oct. '42)

Chaney, Lee F., Star Route Box 306, Tacoma, Wash. (Apr. '44) *P*

Clark, Howard F., Chief Engr. & Gen. Mgr., Cino Basin Munic. Water Dist., 121 N. Plum Ave., Ontario, Calif. (July '50)

Clark, Paul L., *see* Media (Pa.)

Cochran, Omar Neil, 339½ Windsor St., Marion, Ohio (Jan. '51)

Cranch, Eugene T., 28 Majorca Ave., Apt. 2, Coral Gables, Fla. (Mar. '22) *M*

Devilbiss, Howard Roland, Deputy Chief Engr., Washington Suburban San. Dist., Hyattsville, Md. (Apr. '22) *MR*

Dixon, Crawford M., *see* Boulder (Colo.) Water Dept.

Eidsness, Fred A., Consultant, 700 S.E. 3rd St., Gainesville, Fla. (May '41) *Fuller Award 44. P*

Ewing, Benjamin Baugh, Asst. Prof., Civ. Eng. Dept., Univ. of Texas, Austin 12, Tex. (Jan. '48) *P*

Faber, Harry A., Assoc. Editor, *Water & Sewage Works,* 155 E. 44th St., New York, N.Y. (July '35) *Diven Medal '48. Goodell Prize '49. P*

Garden City, City of, Walter Baker, Supt. of Utilities, Garden City, Kan. (Corp. M. Jan. '50) *MPR*

(*Continued on page 44*)

(*Continued from page 42*)

Goudy, M. P., *see* Arizona Public Service Co.

Goudy, Maynard P., Arizona Public Service Co., Box 2501, Phoenix, Ariz. (Oct. '49)

Granger, Dale W., 3626 N. Grand River Ave., Lansing 6, Mich. (Jan. '51)

Harris, John P., John P. Harris, Inc., 1791 W. Howard St., Chicago 26, Ill. (Oct. '33) *P*

Hoge, Charles C., III, State Dept. of Health, 413 First National Bank Bldg., Greensburg, Pa. (Jan. '50) *PR*

Hosegood, Leslie A., *see* San Bernardino (Calif.) Board of Water Comrs.

Hosegood, Leslie A., Supt., Board of Water Comrs., 195 D St., San Bernardino, Calif. (Oct. '43) *M*

Huntington, Ben, Engr., Water Lines, City Water Dept., 2425 Evergreen St., San Diego 6, Calif. (Oct. '50)

Johnson, Charles Ross, 566 Scenic Dr., San Anselmo, Calif. (Oct. '50)

Johnson, Elmer A., Cons. Engr., E. A. Johnson & Assocs., 2122 J St., Sacramento, Calif. (Jan. '51) *PR*

Jones, Hugh, Mgr., Gen. Constr. Div., Hood Constr. Co., Box 112, Lynwood, Calif. (Jan. '47)

Kukurin, Frank, & Sons, Inc., George W. Kukurin, Secy., 616 Greensburg Ave., East McKeesport, Pa. (Assoc, M. Jan. '51)

Lavoie, Edouard, Delisle & Laquerre, Civ. Engrs., 365 Racine St., Chicoutimi, Que. (Apr. '49)

Maclure, James H., Cons. Engr., 3 Malcolm Circle, Dorval, Que. (July '51)

Mannel, Charles, Civ. Engr., Box 525, Asheville, N.C. (Oct. '45)

McLarty, William J., Sanitation Field Repr., State Office of Civ. Defense, 839 Phelan Bldg., 760 Market St., San Francisco, Calif. (Jan. '51) *P*

McRae, J. Percy, McRae Eng. Equipment, Ltd., 100 Adelaide St., W., Toronto, Ont. (Jan. '24)

Media, Borough of, Paul L. Clark, Supt., Water Dept., State & Jackson Sts., Media, Pa. (Corp. M. Jan. '45) *MP*

Montel, Joseph I., Chem. Engr., Hammond-Montel, Inc., 50 Church St., New York 7, N.Y. (Jan. '50) *P*

Morris, Kenneth L., Branch Mgr., Suffolk County Water Authority, Box 89, Bayshore, N.Y. (Oct. '45) *M*

Nasi, Kaarlo W., Mutual Security Agency, Public Health Staff, 1000 A Maiatico Bldg., Washington, D.C. (Jan. '38) *P*

Nassau County Dept. of Health, Arthur H. Herberger, Div. of Sanitation, 1053 Franklin Ave., Garden City, N.Y. (Mun. Sv. Sub. Apr. '40)

Newnam, F. H., Cons. Engr., Water Dept., Beaumont, Tex. (Jan. '44)

Nutting, N. C., Distr. Mgr., California Water Service Co., 1840 Salvio St., Concord, Calif. (Sept. '33)

Oklahoma A. & M. College Treatment Plant, Lawrence Paxton, Operator, Stillwater, Okla. (Corp. M. Jan. '51) *P*

Paxton, Lawrence, *see* Oklahoma A. & M. College Treatment Plant

Pearson, Dudley C., 511 W. Belleview St., Porterville, Calif. (July '51) *MPR*

Pryor, Orval W., 932½ E. 7th St., Pueblo, Colo. (Jan. '49)

Ramseier, Roy Edwin, San. & Hydr. Engr., 2082 Center St., Berkeley 4, Calif. (Apr. '39) *MPR*

Richards, Robert B., Wyndover Lane, Stamford, Conn. (Jan. '43)

San Bernardino Board of Water Comrs., Leslie A. Hosegood, Supt., City Hall, San Bernardino, Calif. (Corp. M. Nov. '33) *MPR*

Seevers, F. R., Sales Repr., Mueller Co., 2409 B St., Lincoln, Neb. (Jan. '51) *MPR*

Silcox, H. E., 1214 Nottoway Ave., Richmond 27, Va. (Jan. '42) *PR*

Somers, Donald McLean, 108-49 Union Turnpike, Forest Hills, N.Y. (July '49)

Taylor, C. M., Director of Public Service, 130 East St., Oneonta, N.Y. (July '48) *MP*

Timmers, Harold J., Jr., Sales Engr., Johns Manville Sales Corp., 3033 Sheridan Rd., Chicago, Ill. (Jan. '52)

Truscott, L. H., c/o T. Bishop, 1137 Dorchester Ave., Calgary, Alta. (July '50) *MP*

Weber, George, Jr., 104 S. 27th St., Camp Hill, Pa. (Apr. '50) *MPR*

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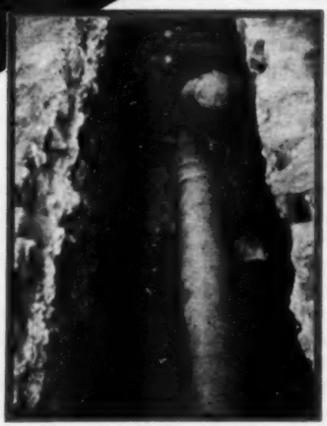

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Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

CHEMICAL ANALYSIS

1950 Supplement to Book of ASTM Standards. Part 5. AM. SOC. TESTING MATERIALS. Philadelphia, Pa. (1951), 600 pp. This supplement to Part V of the 1949 Book of ASTM Standards includes (pp. 467–513) revised methods of expressing results of chem. analyses of water for use in industry and new definitions of some terms relating to industrial water supplies and to trade waste waters. Tentative methods are given for detg. total carbon dioxide, silicon, sodium, potassium, hardness, and electrical conductivity, for identification by X-ray diffraction of crystalline compounds in water-formed deposits, and for the identification of microorganisms in water. A tentative standard for preparing a synthetic sea water is also included (pp. 514–515).—*WPA.*

Diagrams Illustrating the Chemical Composition of Drinking Waters. JANOS PATER. Hidrol. Közlöny (Hung.), **30**:428 ('50). For the quick prepn. of diagrams showing the most important data for drinking waters, a system of 3 coördinates is used. One coördinate serves for plotting the values of alky., total hardness, and total solids, another for sulfate, chloride, and nitrate contents, and a third for O consumption and nitrite and NH_3 content. The basic coördinates show the std. values of good drinking waters. If the respective values for a water sample are above or below the std. data, the value is plotted above or below the coördinate. Thus the triangular diagram shows instantaneously whether the water is above or below the stds. of a good drinking water.—*CA.*

Determination of Arsenic in Water. V. YA. EREMENKO. Hydrochem. Material (U.S.S.R.), **16**:15 ('49). The spot-filtration method by Saterlee and Blodgett is more sensitive and accurate than the Zanger-Black method. For As content of 0.01–0.7 γ, the error did not exceed 0.01 abs. For over 0.7 γ, error rises rapidly and for over 1 γ, detn. is impossible because of darkening of the field. In making the detn., add 50 ml concd. HCl to 100 ml of water to be analyzed, add 7 g Zn, maintain vacuum at 570 mm at first (for intensive sepn. of H_2), and then at 380 mm, and after 30 min, treat disks with 10% KI soln., wash, dry, and compare spots.—*CA.*

Colorimetric Method for Routine Estimation of Calcium in Natural Waters. F. J. H. MACKERETH. Analyst (Br.), **76**:482 ('51). In a 10-ml Pyrex centrifuge tube, with the tip drawn out, put sufficient water to contain 10–100 γ of Ca. Add 3 ml of satd., aq. picrolonic acid soln. and rub the inside of the tube with a stainless steel rod, tipped with a small rubber sleeve. Wash off the rod with distd. water. After standing 3 hr in the stoppered tube to prevent evapn., centrifuge 5 min at 2000 rpm. Decant the soln. and half-fill the tube with satd. Ca picrolonate soln. and gently blow the ppt. into the body of the tube by a fine jet of this satd. soln. from a

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wash bottle. Wash the ppt., dissolve it in 60% EtOH, and compare the yellow color with stds.—*CA.*

Indirect Determination of Calcium and Strontium. Carlo Sampietro & Ida Invernizzi. Ann. chim. applicata. (Ital.), **39**:613 ('49). Both Ca and Sr can be detd. in artificial mineral waters by removing group I and IV cations and then pptg. CaC_2O_4 and $Mg_2C_2O_4$ with a known vol. of std. $H_2C_2O_4$ or $(NH_4)_2C_2O_4$ soln. The excess oxalate is measured by $KMnO_4$ titration or by igniting the oxalates and weighing the oxides.—*CA.*

The Determination of Chloride in Water. A. Dangoumau, H. Debruyne, & R. Cluzan. Bul. Soc. Chim. France, **1951**:434. It is difficult to det. differences of 5–6 mg/l of Cl as NaCl in water by the usual Mohr method with 0.05 *N* $AgNO_3$ soln. A potentiometric method was devised which is sensitive to 0.5 mg/l and uses 0.01 *N* $AgNO_3$ soln. Two concn. cells are connected in opposition through a sensitive galvanometer, the reference cell being a Ag wire coated with AgCl by electrolysis and immersed in a *N* soln. of KNO_3 contg. a drop of 0.01 *N* $AgNO_3$, and the unknown cell being a Ag wire immersed in the water being analyzed to which about 1 ml of H_2SO_4 per 100 ml has been added. The cells are connected by an electrolyte-gel bridge. 0.01 *N* $AgNO_3$ is added dropwise to the water with agitation while the circuit between the cells is intermittently closed by means of a key. When no deflection of the galvanometer is obtained, the end point has been reached. The precision is reported to be $\pm$ 0.3 mg/l of NaCl.—*CA.*

Precise Colorimetric Determination of the Fluoride Ion. S. Lacroix & M. Labalade. Ann. Chim. (Fr.), **4**: 68 (1950). To det. fluoride, hydrofluosilicic acid is distilled off into a

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soln. of caustic soda by heating the sample with *o*-phosphoric acid to 200 C in a flask of ordinary glass. The soln. in caustic soda is buffered to pH 2.9 with chloracetic acid and a small quantity of a soln. of 5% sulfo-5-salicylic acid contg. ferric iron is added. Fluorine reacts with the ferric iron, causing the violet color of the reagent to disappear. A calibration curve can be prepd. by adding known amts. of fluoride to a given volume of the reagent and comparing the loss in color at a controlled temperature.—*WPA*.

Detection of Trace Quantities of Radioactive Materials in Waste Streams. PAUL R. FIELDS & GRAY L. PYLE. Anal. Chem., **23**:1004 ('51). A general discussion is presented on radiochemistry for waste-disposal scientists. Two elements, U as an α emitter and I^{131} as a β emitter, are taken as representative samples of the two types. The detn. of microquantities of these two materials is reviewed including a fluorophotometric method and a radiochem. method of analyzing for U.—*CA*.

FILTRATION

Construction and Operation of Rapid Gravity and Pressure Filters. International Wtr. Supply Assn. Congress, Amsterdam. **Report IV**:519 ('49). A survey based on reports from Belgium, China, France, Great Britain, the Netherlands, Sweden, and Switzerland, has been made by BUYDENS, R., of the construction and operation of rapid gravity and pressure filters for the treatment of water. A summary of each report is given and includes information on the type, size, and depth of medium used, construction of filters, rates of filtration, operation of filters including washing, methods and equipment used for examg. the treated water, and results obtained. An acct. is given of exptl. work carried out in Sweden to det. the depth of sand necessary for max. efficiency of filtration; the method is based on the changes in pressure with depth of medium and length of filter run. In discussing the washing of filters, diagrams are given of the Wabag filters in use at Lovön, Sweden; the surface of the sand is kept free from mud balls by backwashing with air and water, applied simultaneously and distributed evenly and at uniform pressure throughout the bed. A graph is given showing the relations between sand expansion, size of grain, rate of washing, and loss of head.—*WPA*.

Filter Sweeps. EDWARD S. HOPKINS. Proc. Ann. Conf. Md.-Del. W. & Sew. Assn., **24**:10 ('51). Efficient water filtration through sand filters depends on a graded, uniform, smooth

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sand bed. The installation of Palmer sweeps for surface washing is economically feasible and will prevent accumulation of mud deposits in a sand bed.—*CA*.

Salina, Kan., Uses High-Rate Filters. LESTER T. HAGEDORN. Am. City, **46**:9:96 ('51). Combined domestic and industrial wastes are treated in a plant providing primary settling, 2 high-rate trickling filters 116½ ft in diam. with recirculation rate of 1 : 1, heat exchanger for sludge, and sludge digestion.—*CA*.

Water Filter of Diatomaceous Earth and Activated Carbon. HERBERT E. HUDSON JR. U.S. Patent 2,555,970 (June 5, '51). Upon the porous septum of a filter box is spread a layer $\frac{1}{16}$–$\frac{1}{8}$-in. thick of diatomaceous earth, and on it is applied a slurry of active C passing a 100-mesh screen but contained by a 400-mesh screen, in the proportion of 1 lb C to 3 lb diatomaceous earth. The slurry is applied under a pressure of approx. 5 psi and forms a layer $\frac{1}{8}$–$\frac{3}{4}$-in. thick. The formed layers cause a loss of head of 3–25 lb/sq ft under ordinary conditions and can treat 40–1000 gal water/sq ft/run.—*CA*.

A Method of Washing Filter Sand. MARCEL LAVAL. J. Inst. Wtr. Engrs. (Br.), **6**:155 (Mar. '52). In washing sand on slow sand filters in Paris, area to be washed is enclosed by long, bottomless box, approx. 8.48 m long and 35 cm wide. Box is 55 cm high and penetrates approx. 5 cm into sand, forming coffer dam enclosing 3 sq m of sand surface. Pipe grill is lowered into full depth of sand and water under pressure stirs up sand while suction pump withdraws dirty water from box. Sand is washed by upward current of clean water supplied at rate of 30 l per sec for 1 to 1½ min at a pump-

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ing pressure of approx. 10 m. Limiting velocity of dirty water for entraining finest sand is 1 cm per sec. Bed is out of service during cleaning. Consumption of water for washing is barely 2% of total water filtered by bed.—*H. E. Babbitt.*

FOREIGN WATER SUPPLIES

Ground Water Works in Aaretal. A. Teutsch. Schweiz. Ver. Gas-u. Wasserfach. Monats-Bul. (Swiss), **31**:12 ('51). The author gives a detailed illustrated description of the works in Aaretal, Switzerland, from which an addnl. supply is provided for the town of Bern. Since the works were put into operation in 1949, phys., chem., and bact. tests of the water have been made. The results have shown the quality of the water to be satisfactory and there has been no sign of any alteration in quality since the supply has been in use. The other sources from which Bern also draws its supply are described and the need for increasing the storage capac. of the reservoirs is discussed.—*WPA.*

City of Brisbane Water Supply. H. Bowden Fletcher. Wtr. & Wtr. Eng. (Br.), **56**:3 (Jan. '52). Water supply is drawn from inhabited catchment of 4,000 sq mi. Turbidity is at times extremely high. Main source of supply is Brisbane R. 20 mi from city, at Mt. Crosby. Because river supply is sometimes too low, two addnl. dams have been built. Lake Manchester holds 7,000 mil gal (Imp.), and Somerset Dam, now under construction, will hold 55,000 mil gal (Imp.). Water is released from both these reservoirs into Brisbane R. to maintain level at Mt. Crosby pumping station. Total pumping capac. is 96 mgd to treatment plant. Avg. consumption is 60 mgd. First trunk main laid in 1866 was 8-in. in diam. Works now authorized provide for 4.5 mi of 60- and 66-in. mains. Distribution system comprises 1,170 mi pipe ranging from 3 to 24 in. Treatment consists of coagulated sedimentation, filtration, and chlorination. Somerset Dam is a straight gravity, masonry dam approx. 1,000 ft long, 135 ft thick at base, and with max. height of 173 ft. Because of high rainfall and heavy flooding, provision is made for discharge of 165,200 cfs. In 1893, 35 in. fell in one day in northeast part of catchment area, and total of 76 in. fell over four consecutive days, giving runoff estimated at 2,660,000 acre-ft. —*H. E. Babbitt.*

Modernization of Ketford Pumping Station for the Gloucester Corporation Water Undertaking. Anon. Wtr. & Wtr. Eng. (Br.), **56**:19 (Jan. '52). Two boreholes, approx. 146 ft deep in Keuper Sandstone, yield 31,000 to 37,000 gph (Imp.) each. Before electrification, plant consisted of duplicate air compressors, each 180 bhp, delivering air into air-lift tubes. New pumping plant consists of Sulzer mixed-flow, 3-stage borehole pump at each borehole, and two Sulzer, three-stage, centrifugal booster pumps for delivering water to two reservoirs. Electric supply is rated at 11,000 v, 3 phase, 50 cycle.—*H. E. Babbitt.*

Water Supply of the City of Hagen, by Means of Water From the River and a City Reservoir. Hans Kohl. Gas-u. Wasserfach (Ger.), **92**:14:171 ('51). Ruhr water is treated in a rapid filtration plant after adding $Al_2(SO_4)_3$ for flocculation. The addn. of Na_2CO_3 is unnecessary. This treated water then flows to infiltration basins. The filter bottom of these basins remains in good condition indefinitely. Water from the wells is pumped directly into the system after chlorination. Water from the elevated reservoir is also treated by rapid fil-

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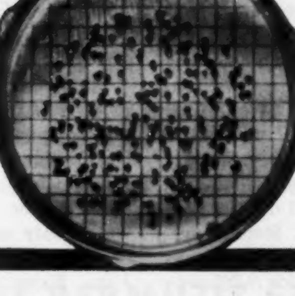
tration after adding $Al_2(SO_4)_3$ and Na_2CO_3. The filtered water is chlorinated.—*CA.*

Studies on Ground Water in the Region of Vevey. R. RITZMANN. R. Monatsbull. Schweiz. Ver. Gas-u. Wasserfach (Swiss), **31**:1 ('51) (in French). The author reviews briefly the principal sources of ground water supply in the vicinity of Vevey and Montreux, on the shores of Lake Geneva. There are, at present, no large sources at Vevey, which depends largely on overflow from regions higher in the mountains and which suffers during periods of drought. The total supply available at present varies from 11,000 to 30,000 l per min. In 1949, the demand was 13,800 l per min and on some days exceeded 18,000 l per min. Various sources of supplementary supplies have been considered and studies have been made to det. the possibilities of obtaining further supplies from alluvial deposits at the mouth of the Veveyse. These studies included the nature of the deposits, the level of the ground water, pumping tests, and phys., chem., and bact. analyses of the water. There is a large vol. of water available in these deposits and it is recharged by infiltration of rain water and by lateral infiltration of water from the lake. The level of the water table follows the fluctuations in the level of the lake. In addition there may be some infiltration of water from the Veveyse and by leakage from sewerage and water-supply systems. The ground water is of a satisfactory bact. quality after filtration through the alluvial deposits. It is harder than the water of the lake and contains some nitrites and little oxygen. As a result of these studies, two exptl. wells are to be constructed and, if their performance is satisfactory, more will be provided. It is suggested that wells should be situated near the edge of the

(Continued on page 60)



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lake as the water there is softer; that water should be drawn from a depth of at least 30 m; that several small wells drawing low supplies from small areas are preferable, to prevent large movements of ground water with consequent changes in composition; that an area of at least 100 m around each well should be protected from poln; that the water should be disinfected before delivery to the distribution system; and that regular chem. and bact. analyses should be made.—*WPA.*

Ground Water for the Vienna Water Supply. A. STEINWENDER. Gas, Wasser, Wärme (Aust.), **5**:248 (Oct. '51). Since 1893, consideration has been given to four different drainage basins near Vienna for subsurface supplies. During World War II, aqueducts were subject to bombing and ground water supplies were developed within the city boundaries for 50,000 cu m/day. After the war, industrial requirements were 250,000 cu m/day or approx. 25,000 cu m more than that available in the developed district. In 1950, the total water from long-distance spring and well supplies was 130 mil cu m/year of which 9.2% was ground water. Since the long distance mountain springs do not supply water the year around, the total percentage of ground water used is approx. 40%. Well water is considered more desirable and less costly than spring water. —*W. Rudolfs.*

Ground Water for Vienna. A. STEINWENDER. Gas, Wasser, Wärme (Aust.), **5**:265 (Nov. '51). The avg. pptn., which varies between 600 and 1092 mm, gives calcd. values of 300,000 to 600,000 cu m/day in the Neustad-Wiener profile. Since in the driest period, winter, pptn. is in the form of snow with low temps., infiltration is low and yield of springs only a fraction of the average pptn. Measurements of ground water velocity vary between 0.1 and 22 mm, indicating that great care must be taken to interpret avg. ground water velocity figures. The eventual supply of spring water is insufficient and must be supplemented by well water.—*W. Rudolfs.*

SERVICES AND METERS

The Effects of Alkathene Upon Water Quality. E. F. W. MACKENZIE. J. Inst. Wtr. Engrs. (Br.), **5**:596 (Oct. '51). Alkathene is a trade name of a polymerized ethylene variety of plastic made in Great Britain by Imperial Chemical Industries, Ltd. It is made for the conveyance of cold water only and is available in pipes having an internal diam. of $\frac{1}{2}$, $\frac{3}{4}$, and 1 in. Expts. were made solely to det. effect on waters of Metropolitan Water Board, London. It was concluded that: [1] the material has an inherent ability to impart taste to water but it has not been ascertained exactly under what conditions; [2] as long as metals are difficult to obtain, the use of alka-

(*Continued on page 62*)

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WATER CONDITIONING HEADQUARTERS FOR 40 YEARS

(*Continued from page 60*)

thene is justified for small service pipes and internal piping; [3] it is inadvisable to approve alkathene as piping in large buildings involving long runs; [4] alkathene is particularly suitable for the conveyance of strong solns. of chlorine, sulfur dioxide, and possibly other corrosive substances.—*H. E. Babbitt.*

Experiences With Plastic Pipes by the East Gelderland Water Distribution System, Inc. Water (Neth.), **36**:65 (Mar. '52). About 150 service lines were made of plastic material. Installation must be carefully executed. Cutting of pipes should be slow to prevent temperature rises. Soldering is replaced by gluing with heat. At 100 C the pipes bent readily. After glueing, the connection cannot be heated again.—*W. Rudolfs.*

Erosion of Domestic Water Fittings. S. G. Barrett. J. Inst. Wtr. Engrs. (Br.), **6**:145 (Mar. '52). Author's researches were upon ball valve seatings passing Newcastle water under erosion conditions. More cast fittings failed than did hot-pressed fittings. Many more bib taps failed than ball valves. Outstanding conclusion from test is that corrosion of hot-pressed brass in ball valve seatings is rapidly accelerated by chlorine in water. Tests indicate that min. pressure in region of 60 psi will bring about speedy destruction of brass taps. In Newcastle, evidence indicates that tap made of aluminum brass would last nearly 20 times longer than tap of standard brass.—*H. E. Babbitt.*

Economics of Water Metering. F. Bartos. Gas, Wasser, Wärme (Aust.), **5**:228 (Sept. '51). An aftermath of the war is greatly increased water losses. In Vienna, water losses before the war averaged 14%, during and after the war 28%, and 23% in 1950. Losses are due to broken pipes,

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poor meters, and approx. 5% on account of old, leaky pipes. About 62% of the meters are overage and do not begin to measure until the velocity is approx. 200 l/hr, hence much water is lost (unmetered) and not paid for. The domestic water consumption is approx. 50 l/cap./day. Total industrial and domestic water consumption is 200 l/cap./day. Calculations show that it pays to repair or replace meters which have been in operation 6–12 yr. —*W. Rudolfs.*

Some Problems Concerning Distribution of Water. RESEARCH GROUP J. J. Inst. Wtr. Engrs. (Br.), **6**:110 (Mar. '52). The aim of the investigation was to produce lead pipe with all the proved advantages of this material, at competitive market prices. Lead is adapted to irregular surfaces and possesses sufficient ductility to enable it to be shaped to requirements. The normal type of wiped plumber's joint is reputed to be stronger than pipe itself. Except for plumbo solvency, its corrosive-resistant properties are well recognized. Main disadvantage is liability to damage by frost. Pipe having ¾-in. diam. was studied initially. Tests indicate max. safe continuous working pressure lies between 350 and 400 psi. Pipe is reinforced with bronze tape. The pipe has many advantages: it is flexible; weighs less than standard pipe; is lagged, with advantage of low heat loss; allows transmission of sound; has reasonable degree of mechanical protection; polyvinyl chloride-sheathed pipes can be supplied in any color; hessian-finished pipes are suitable for installation in normal soils; special protection can be applied where soils are abnormal; pipes can be reinforced with wire armor; and pipes up to 3 in. in diam. can be supplied. Pipe couplings can be made from lead. The plumber's wiped joint is the most widely used lead joint. Simpler soldered joints or those made by copper soldering are reliable but unsightly. Lead-burned joints require bulky equipment and usually take longer to make than other types of soldered joints. A mechanical coupler for lead pipe of the flanged variety is reliable. Principle of flanging has also been used for connection of tin-encased lead pipe. It is concluded that wiped-soldered joints are generally superior, simpler to make, and cheaper than any method known at present. Since the recent increase in use of soft copper tubing for underground purposes, several manufacturers of compression joints have made efforts to adapt their nonmanipulative joints to those of manipulative variety while at the same time retaining the normal fitting and cap or threaded union. An alternative method for protecting storage tanks from rust is the use of mild steel and iron storage cisterns rather than lead or copper cisterns. Cast-iron, sectionalized storage tanks require special structural considerations and, where possible, are usually avoided. Manufacturing difficulties limit capacity of ceramicware storage vessels. The cost of slate as a water container is prohibitive. The copper-lined cistern is apparently losing favor as a result of the timber shortage. High cost of sheet lead is added disadvantage in lead-lined tank. Choice of bituminous coatings for fresh-water storage is mostly restricted to bitumens of petroleum origin, owing to their freedom from tainting and flexibility over normal range of temperatures. The bituminous coatings are usually limited to the normal temperature range by their permanent thermoplastic character. Adoption of rust-inhibitor water treatment system designed to give self-sealing phosphate coating, automatically replaced when broken, offers approach to protection problem. Sacrificial and applied protection have been used in protecting pipelines and well casings, but their adaptation to

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domestic storage cisterns has not yet proved attractive in England. Anodizing process for aluminum might be applied to water-storage tanks. The coat of aluminum oxide is applied by electrolytic process in which the metal is suspended in bath of chromic acid and acts as anode. Aluminum alloy tanks for drinking water on aircraft are covered on inside with coat of clear varnish. Fresh-water tank interiors are being electroplated with sea water. A deposit of magnesium chloride acts as the lining. Vitreous enamelling has been suggested. If tanks were suitably designed, it would be possible to coat them with vitreous enamel. Phosphating process is used for rustproofing in automobile industry. Phosphate coatings, in general, are not, in themselves, rustproof. They are usually tightly adherent and absorbent and constitute ideal base for subsequent application of organic coatings, such as drying oils or primer paint. Lining can be produced by bonding thermosetting plastic materials to prepared surface of metals by baking process. Three-ply Duralumins, used in aircraft industry, might be applied to storage cisterns. Likewise, resin-bonded glass fabric, as applied in construction of boat hulls, is strong and light and might be used in construction of domestic cisterns. Plastic material, composed of special resin and chemically inert filling, is tough and strong, and is unaffected by temp. up to 265 F. It would appear suitable for storage tanks. Cisterns of asbestos are usually limited to smaller capacs., and material is influenced by frost. Metal spraying has apparently not been adapted to protection against water corrosion in domestic water tanks. In general, industry is not favorably inclined toward use of plastics or plastic linings. Polymerized ethylene (Polythene) tubes are light, flexible, immune from corrosion, can be bent to small radius curves, and will withstand repeated freezing and thawing. There is general lack of experience with them, however. They are unable to transmit sound, unsuitable for water above 120 F., soft and easily damaged, unable to transmit electricity, combustible, prone to damage by rats, and have high coef. of linear expansion. Polyvinyl chloride pipes have similar advantages and disadvantages, and will not withstand as high pressures as Polythene.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

Rainmakers Competing for Work Sign Performance Contracts. Eng. News-Rec., **148**:15:70 (Apr. 10, '52).

The Filters Can Be Smaller. Louis J. Horn. Am. City, **66**:11:100 ('51).

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Dry hydrotherapy for canine neuroses sounds like a matter for the Humane Society, and actually it is, up in Toronto. But actually, too, it is the Humane Society that is applying the dry hydrotherapy, claiming that the dryness is not the least bit inhumane as the dogs don't know it—and what they don't know can, apparently, help them. Anyway, the Toronto chapter of the society for the prevention of cruelty to animals, neuropsychological division, has taken over the city's retired fire hydrants and installed them—unconnected—in its outdoor kennels "to calm canine nerves which may be upset by the unfamiliar journey there." Since the hydrants are dry (i.e., not connected) we can take no professional umbrage, but our personal feeling for faithful old servants is aroused. After all, if it is true, as we have always been led to believe, that the canine fondness for hydrants stems from some canine fight fire with fire precept, then even a mongrel, no matter how neurotic, would call it poor sportsmanship to pick on a defenseless opponent.

Stuart Smith Jr. has joined the staff of Neptune Meter Co. and will assist M. J. Siebert in water meter sales in Virginia, Maryland, and West Virginia.

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Frustration on three water fronts—stretching all the way from source to consumer—made news at least worth noting:

First, as a matter of source, the good citizens of Leghorn, Italy, were more than flabbergasted last month by the "luck" of the U.S. Army stationed there. Plagued by an inadequate water supply itself, the city was unable to grant the Army command all the water it requested. Army engineers then dug a "useless" well, which at 170 ft tapped a 250-gpm supply of a mineral water that sells in Italy for 20 cents a bottle.

Second, distributionally, in Springfield, Mass., a landlubber Ancient Mariner sat at the helm of his city street-sprinkling truck water-water-everywhereing it while he watched his short-circuited engine burn because he needed the engine to get at the hundreds of gallons of water behind his left ear.

Third, consumerwise, the British Horse Trough Association announced the availability of two dozen spare troughs, indicating that its business was poorer than at any time since the association was formed in 1859.

Even in these backwaters of the news, it becomes quite clear that civilization mechanizes on, though whether the end will be post-robot or pre-horsetrough we're almost afraid to guess.

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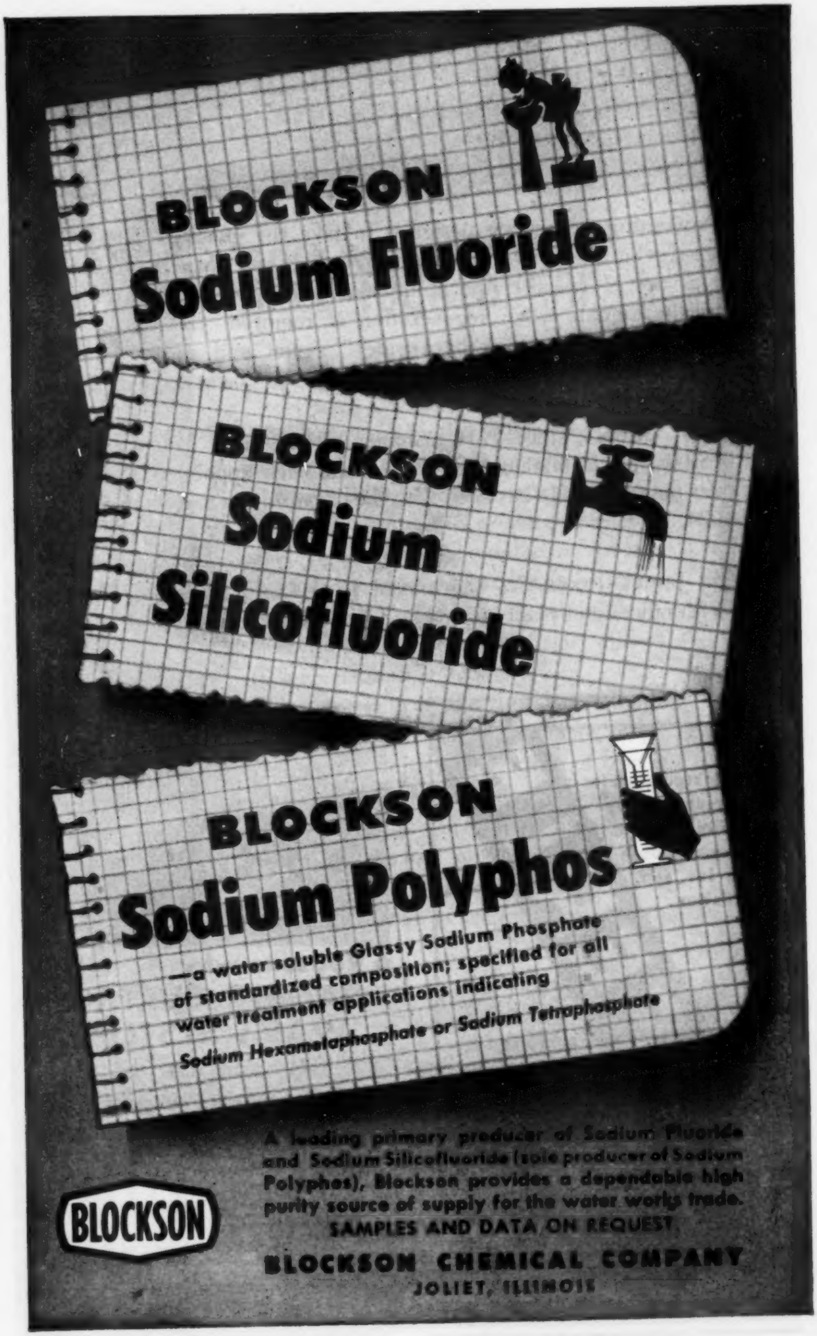
BLOCKSON
Sodium Fluoride
BLOCKSON
Sodium
Silicofluoride
BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST
BLOCKSON
BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS

(Continued from page 70)

Not just ill wind any more, but ill water, too, brings good. Unfortunately, however, the best the recent Missouri flood could muster was two catfish, which water superintendent Herbert Treadway caught on South Sioux City's main street while on an inspection cruise.

A softening accessory designed to take the guesswork out of ion-exchange regeneration has been developed by Refinite Corp. of Omaha, Neb. Known as the Hyramizer, the unit makes a soap test for hardness and automatically signals when regeneration is required. If the softener is operated automatically, the "hard-water" signal will actuate the valve mechanism. The unit is small and is said to be simple and inexpensive.

M. D. Gilbert, since 1944 manager of the Tulsa district for Rockwell's Pittsburgh Equitable Meter Div., has been appointed Kansas City Dist. sales manager. He has been with the organization and its predecessors since 1924.

The James Jones Co. has moved from Los Angeles to El Monte, Calif., with offices and plant located at 321 N. Temple City Blvd.


SELL YOUR SCRAP
to keep steel production up
Rising steel production depends on an increasing flow of scrap. Your scrap is needed!
About 1000 pounds of iron and steel scrap are required to produce one ton of steel. Now, with steel production greatly expanded to meet military and civilian requirements, more scrap is essential. Every pound is important if steel mills are to keep running at capacity.
You can help by checking your pumping and treatment plants, maintenance shops and storage yards for all kinds of iron and steel scrap. Collect worn-out or obsolete parts and equipment — pipe, fittings, tools, pumps — then call your scrap dealer.
But don't stop there. Organize a regular collection system to keep the scrap moving.
ARMCO STEEL CORPORATION
ARMCO
2962 Curtis St., Middletown, O. • Plants and Sales Offices from Coast to Coast • Export: The Armco International Corporation

The Reading Meter

(*Continued from page 22*)

Western Gulf Drainage Basin: *Summary report on water pollution. Water Pollution Series, No. 8; Public Health Service Pub. No. 92; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 68 pp.; paperbound*

This is a cooperative state-federal survey of pollution in the basin that includes most of Texas and New Mexico, and parts of Louisiana and Colorado. The area has a population of more than six millions and, being semi-arid, is dependent for its future economic development—as well as present agricultural production—upon the availability of water. Producing oil wells and the processing of petroleum and of farm products, together with much natural silting, are prominent among causes of pollution. Man-made pollution is particularly damaging in the Sabine Lake, Galveston Bay, Dallas, Fort Worth,

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The Reading Meter

(*Continued from page 74*)

San Antonio, El Paso and the extreme Lower Rio Grande areas. Public sewerage systems serve two-thirds of the basin population, and 94 per cent of this segment is also served by sewage treatment plants. But there are still 212 communities with inadequate or obsolete treatment plants, and 35 with none—some even lacking sewers. As of July 1, 1950, however, plans were being prepared, or plants constructed, by 111 communities.

Southeast Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 13; Public Health Pub. No. 153; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 236 pp.; paperbound*

The Southeast Drainage Basins, covered by this report include approximately one-tenth of the area of the U.S., with a population of

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The Reading Meter

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17,908,000, in the states of Virginia, North and South Carolina, Georgia, Florida, Alabama, and Mississippi. In general the water resources in this region are not being fully exploited, but such use as is being made of them is being increasingly threatened by pollution. Lack of interstate cooperation, insufficient personnel, and inadequate funds are preventing a unified, vigorous attack on the problem. Data are lacking on municipal and, especially, industrial pollution, and, of the existing waste treatment plants, 40 per cent are reported to be of inadequate capacity and 23 per cent to be operated inefficiently. On the credit side, the construction of treatment plants now being planned will add 1,600,000 people to those now served by sewage treatment plants, or nearly one-fourth of the population of the basins. The new construction will also reduce by nearly one-third the sewered population not presently served by treatment works.

Service Lines

A selection guide to electric and electronic controls and accessories manufactured by General Electric Co., Schenectady 5, N.Y., is available upon request. Designated GEA-5781, the 8-page booklet describes the various controls available and their design features.

Chlorine feeders and swimming pool accessories of Everson Mfg. Corp., 214 W. Huron St., Chicago 10, Ill., are featured in a series of booklets available on request. Manual, semiautomatic, and proportional automatic control of the SterElator mechanism are described.

Protective coatings in the Prufcoat line are described, together with applicable service conditions, in a folder distributed by Prufcoat Labs., Inc., 50 E. 42nd St., New York 17, N.Y. A feature of the guide is the index it offers to other technical publications offered by the company.

Ditch diggers—mechanical, of course,—produced by Gar Wood Industries, Inc., Wayne, Mich., are described and illustrated in two bulletins just issued. The Model 314 bulletin describes a heavy duty, wheel type ditcher in the Buckeye line; the Model 303 bulletin is devoted to a medium utility ditcher in the same group.

Motors made by Allis-Chalmers Mfg. Co. are featured in two recent booklets issued by that company, and available on request from it at 1026 S. 70th St., Milwaukee, Wis. Large vertical induction motors are covered in Bul. 05B7629; the squirrel-cage induction type in Bul. 51B7693.

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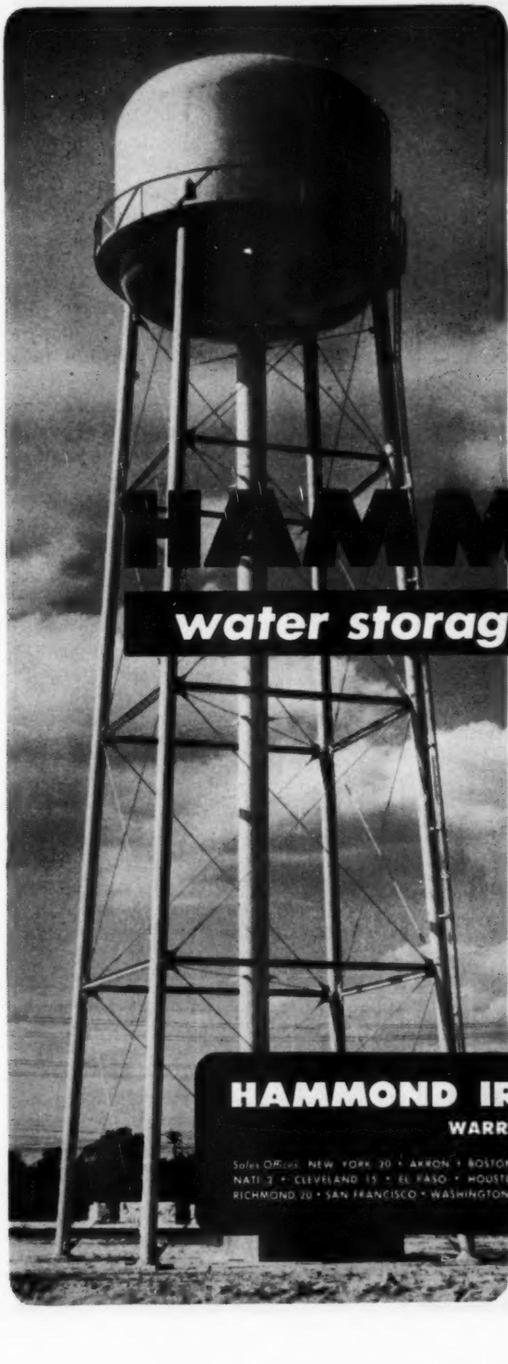

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"Scientific Apparatus and Methods" is the title of a 32-page booklet on laboratory apparatus issued by E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill. In addition to including revisions to the Sargent catalog, the current issue of the house organ quarterly contains discussions of oscillators and electroanalyzers for copper and lead.

A photoelectric colorimeter and turbidimeter known as the Chromatron has been introduced by Hellige Inc., 877 Stewart Ave., Garden City, N.Y., and is described in a circular, Catalog No. 925. The instrument is equipped with color filters covering the entire visible spectrum, uses absorption tubes that are either square or round in cross-section, and features an automatically focused, low wattage lamp bulb. The photocell is hermetically sealed for stable operation, and the entire unit has been designed to withstand rough treatment without loss of accuracy.

"The Water Well Story," a 36-page booklet offered by Mobile Drilling, Inc., 960 N. Pennsylvania St., Indianapolis, Ind., tells a picture-story of the drilling of a small, domestic well with a Mobile Drill. The drill features rotary, auger and percussion drilling on the same rig.

A flow meter handbook for variable-area instruments is offered by Fischer & Porter Co., Hatboro, Pa. The 40-page booklet offers aids to the selection and sizing of variable-area meters.

How long to keep records is the problem which a 20-page booklet offers suggestions for solving. Entitled "A Basic Plan for Record Retention and Destruction," the bulletin, No. X1200, may be obtained upon request from Remington Rand Inc., 315 Fourth Ave., New York 10, N.Y.

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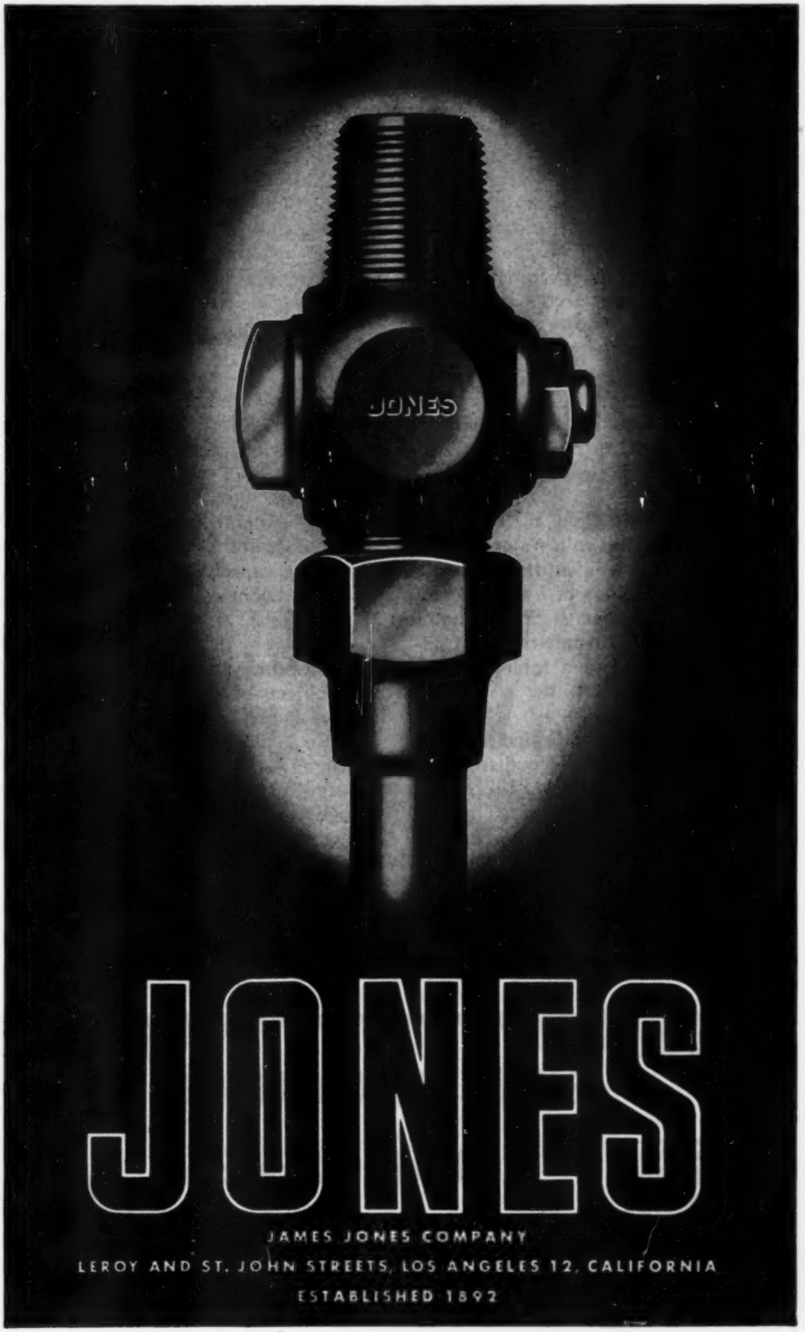
JONES
JONES
JAMES JONES COMPANY
LEROY AND ST. JOHN STREETS, LOS ANGELES 12, CALIFORNIA
ESTABLISHED 1892

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Alternators which change the starting sequence on pumps and other automatically operated equipment are described in a 4-p. bulletin, No. 7100, available from Automatic Control Co., St. Paul 4, Minn. The system is designed to equalize the work load and prevent possible deterioration from disuse. A feature of the alternator is the "locked-in" standby circuit, which provides automatic connection of standby units to controls, thereby providing protection against equipment failure, even in the alternator itself.

Large steel tanks are treated in a 24-page booklet offered for distribution by Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 4, Ill. In addition to describing the operation of the storage tanks in a water system, the booklet, which is entitled "Horton Elevated Steel Tanks of Large Capacity," presents some striking photographs of actual installations. Construction details and a table of sizes are included.

Electronic leak and pipe locators are described in a folder distributed by Fred E. Morgan Co., 1971A W. 111th St., Chicago 43, Ill. The line includes an all-purpose locator as well as specialized units for tracing leaks in mains, plumbing leaks, buried valve boxes or manhole covers, and buried pipe.

Piston-diaphragm pumps for chemical feeding and other applications are the subject of a 24-page bulletin, No. 300, on the Pulsafeeder line. Lapp Insulator Co., Inc., Process Equipment Div., LeRoy, N.Y., is the source. The construction features stuffing box elimination through use of a hydraulically balanced diaphragm, with oil or other suitable hydraulic fluids, propelled by the piston, on one side of the diaphragm and the liquid to be measured on the other side.

A truck-mounted crane, the Pitman Hydra-Lift, is described in a booklet issued by Pitman Mfg. Co., 300 W. 79th Terrace, Kansas City, Mo. The unit, hydraulically powered and suitable for mounting on the frame of 1½-ton or larger trucks, has a loadline capacity of 6,400 lb and a swinging boom which telescopes from 12 to 17 to 22 ft.

Intra-office telephone systems are the subject of an 8-page illustrated booklet available from Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill. Equipment required for the private automatic exchange system is shown and types of service offered are described. P-A-X systems are described ranging from simple units with a capacity of 10 telephones to 200-line units that are indefinitely expansible.

Section Meeting Reports

Illinois Section: The Illinois Section of the American Water Works Assn. held its 42nd annual convention on March 26–28 at the LaSalle Hotel in Chicago. It was by far the best attended meeting that has been held, boasting a total registration of 423. A feature of the program was the arrangement for each formal business session to be preceded by a picture scheduled to hold the interest of the entire group. This practice insured excellent attendance at the opening of each session.

On Wednesday afternoon the genial and very well qualified Edward Alt of the Chicago Bridge and Iron Co., as chairman, formally opened the meeting.

Harold S. Clark, bacteriologist with the U.S. Public Health Service, gave an excellent discussion entitled "Filter Techniques in Water Examinations." This was followed by a most interesting paper by H. H. Gerstein of the South Dist. Filtration Plant in Chicago on "Methods for Testing Water Supplies for Radioactivity." The rest of the afternoon was devoted to papers and discussion on that most important question of fluoridation. Papers were presented by W. J. Downer, assistant chief sanitary engineer of the State Dept. of Health (also this year's recipient of the Fuller Award), and Horace Fry, superintendent from Evanston. George E. Symons moderated the panel that closed this first afternoon session.

Thursday morning was devoted to a most interesting discussion on corrosion problems encountered in water works systems. T. E. Larson, Dewey W. Johnson, John R. Baylis, and E. T. Erickson most ably presented the various aspects of this complicated problem.

As has been the custom, the Thursday morning session was followed by a business luncheon at which time Chairman Alt relinquished his gavel to the incoming chairman, Oscar Gullans of the South Dist. Filtration Plant. The other new officers were H. E. Hudson Jr., vice-chairman; C. W. Klassen, senior trustee; J. Abplanalp, junior trustee; Gerald Davis; and Fred Gordon, who is serving his second year as national director. J. Leslie Hart was again appointed secretary and treasurer.

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Thursday afternoon's activities were opened by Wendell LaDue's paper in which he explained that a water works can make money and not deliver water to individuals. In other words, all it takes is to stock the watershed with some sheep, bees, cattle, hardwood trees, and other hard workers, and these extracurricular activities of the water works will show a substantial profit at the end of the year. This paper was very well received. The rest of the afternoon was devoted to the section's operators. Robert Enzweiler, superintendent of utilities of Park Forest, a real estate development which has gone from scratch to a population of approximately 20,000, discussed with perfect understanding the problems that were encountered and the troubles that may develop in the future.

At the operators' panel discussion of "My Most Difficult Operating Problem Last Year," F. H. King, John H. Blesse, John Krause, Fred F. Penning, Elmo Conrady, and Charles L. Baylor not only explained their problems in an interesting manner but also came up with some ingenious solutions. This session was one of the highlights of the meeting.

The cocktail hour and club room entertainment put on by the manufacturers was among the most enjoyable sessions yet. Mike Foley of the Hersey Manufacturing Co. was chairman of the Club Room Committee, and it was he who furnished the participants with 70 pounds of roast of beef from one of his prize steers.

The annual banquet followed the earlier cocktail party, and chairman Alt so ably presided at this meeting that it will linger long in the memories of the people present.

Three past-presidents—LaDue, Veatch, and Howson—joined the present incumbent, A. E. Berry, at the head table. Dr. Berry offered some most interesting remarks on Canadian and U.S. relationships.

The Fuller Award for 1952 was announced at the dinner and Frank Amsbary announced that the award would go to William J. Downer, that amiable sanitary engineer from the State Dept. of Public Health.

Dr. Berry officiated at the presentation of the certificates to the Life Members of AWWA. This is a new category for persons who have been in the Association 30 years or more.

The group adjourned back to the club room for entertainment and U. H. Foley, W. W. Wolfe, C. H. Evans, and J. C. Barksdale put on a most interesting party. A magician worked from table to table throughout the entire evening of dancing, and 20 door prizes were awarded during the session. All ladies in attendance were presented with a flower. This committee did an excellent job in the staging and preparation for the evening.

On Friday morning the section instituted a new type of program, appealing directly to the industrial water users of the state. Papers by W. J. Roberts of the State Water Survey, W. J. Lauterbach of the Corn Products

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Refining Co., M. D. Sanders of Swift & Co., and C. J. McLean from the Public Service Co. of Northern Illinois were very well presented and received. The reaction to these papers was such that the board decided to repeat this activity next year.

J. Leslie Hart
Secretary-Treasurer

Arizona Section: The 1952 annual meeting of the Arizona Section was held in conjunction with the Arizona Sewage & Water Works Assn. meeting at the Maricopa Inn in Mesa on April 3, 4, and 5, 1952. The total registration at the meeting, including members, ladies, and guests, amounted to 173.

Stuart P. Henderson, superintendent of water at Prescott, called the meeting to order Thursday morning. Mayor O. V. Crismon extended a cordial welcome to the meeting on behalf of the city of Mesa, and arranged for windshield stickers, authorizing free parking, to be made available to all members.

The technical session opened Thursday morning with a paper on "Main Line Meters" by John L. Mapes of the Sparling Meter Co. Paul Hennessy, sales engineer with Builders-Pacific, Inc., presented a paper prepared by C. G. Richardson, vice-president of Builders-Providence, Inc., on "Venturi Meters." The morning session closed with a paper on "Control Instrumentation" in which Emery Ferree, with the aid of models, explained the basic principles of instrumentation and some of their applications to the sewage and water works field.

The Thursday afternoon session with John Rauscher, engineer for the Tucson Water Dept., presiding, opened with a discussion of "The Pitometer" by W. H. Wallace, Berkeley Engineering Co. The film, "Mobilized Sewer Cleaning," made available by Ace Pipe Cleaning Contractors, Inc., of Kansas City, Mo., was well received. Richard Bennett, hydraulic engineer for Phoenix, presented some novel ideas in his paper "Measurements in Flow Line." "Simple Hydraulics for Operators" was the subject John Schaefer, civil engineer with Yost & Gardner, Phoenix, presented very ably.

No official function was scheduled for Thursday night, but an unofficial gathering of the clan was held at Mesa's unusual restaurant, The Feed Bag.

George W. Marx, Arizona state sanitary engineer, presided at the Friday morning sesson, which opened with a paper by Lucy T. Whyman, Arizona's only lady water company operator, on "The Problems of a Lady Operator." Her paper also offered some interesting sidelights on early-day Arizona. Roy O. Hilbrant, foreman with the Phoenix Water Dept., explained and demonstrated features and differences in "Corporation Cocks."

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Various aspects of the "Controlled Materials Plan (CMP-4c)" affecting sewage and water works were explained by Perry C. Tummins of Phoenix. President Boyce of the Federation of Sewage and Industrial Wastes Associations brought the morning session to a close with his paper, "The Federation's Silver Anniversary—25 Years of Progress."

The Friday luncheon was followed by the annual business meeting at which committee reports were received and officers for the ensuing year were elected.

The Technical Session resumed Friday afternoon with Walter Harford presiding. A. A. Kalinske, research engineer with Infilco, Inc., presented a paper on "High Rate Water and Sewage Treatment."

A "Review of Chlorination" was the subject of the paper by Otto Bejeck, sales engineer with Wallace & Tiernan Co. The paper "Flow of Water in Culverts" was presented by John G. Hendrickson, research engineer with the American Concrete Pipe Assn. Half in fun and half in sincerity, this paper was voted the paper with the most polysyllabic words and the author was presented with a silver loving cup at the dinner-dance Saturday night. Fred G. Nelson of the Dorr Co. concluded the afternoon session with a talk entitled "Western and Eastern Sewage."

Friday night, a banquet was held at which AWWA President-Elect Charles Capen reported on Association activities. President Earnest Boyce of the FSIWA extended greetings from the Federation and presented the Bedell Award Certificate to Harold Yost of Yost & Gardner. Barry Goldwater, president of Goldwater, Inc., and Phoenix City councilman, showed films taken during his fishing trip on the Middle Fork River in Idaho. The film and accompanying remarks were well received by members and guests.

Robert Cushing opened the Saturday morning session by introducing President-Elect Capen, who spoke on "Water Developments—Past, Present, and Future."

The Phoenix weatherman, Louis R. Jurwitz, meteorologist in charge of the Weather Bureau, explained hows and whys of "Rainfall in Arizona." He also explained why the weatherman occasionally misses a forecast and why it always rains on the Fourth of July. John A. Baumgartner, assistant district engineer with the U.S. Geological Survey, explained what eventually happens to the precipitation that falls on Arizona (in the off-tourist season) in his talk on "Surface Flows in Arizona."

Vice-President M. V. Ellis of AS&WWA presided at the Saturday afternoon session. The following papers were presented during that period: "Ground Water Resources" by Leonard C. Halpenny, acting district engineer, Ground Water Branch, U.S. Geological Survey; "Pumping From Ground Water Resources" by Harvey Drew; "Peerless Pump and

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Mesa Wells" by Tom Nesbitt of Mesa. The showing of the General Electric Co. film, "Pipeline to the Clouds" received many favorable comments.

E. G. Carder presided as master of ceremonies for the Saturday evening dinner-dance. Harold Yost announced that Guy A. Rhoads of Safford has been selected as the Arizona Section member to receive the Fuller Award for the year 1952. The award was "for honest, sincere and efficient endeavor, and gentlemanly rectitude in the management of the municipal water system for the town of Safford." Alden "Dusty" Miller pH7-initiated Earnest Boyce, Charles H. Capen, Tom Nesbitt, Lucy Whyman, R. Gail Baker, and Harry S. Jordan into the Select Society of Sanitary Sludge Shovelers. President S. P. Henderson turned the meeting over to President-Elect M. P. Goudy, who officially closed the 1952 Annual Meeting of the Arizona Sewage and Water Works Association.

HARRY S. JORDAN
Secretary-Treasurer

Montana Section: The 27th annual meeting of the Montana Section was called to order on April 11 by Chairman M. E. Henderson. Mayor T. T. Rowe of Billings welcomed the 108 members and guests and 54 ladies to the city and expressed the hope that their stay in Billings would be enjoyable. Past-Chairman Harry McCann delivered a response to the mayor's welcome.

John B. Hazen, national director for the section, reported on the Board of Director's meeting in New York. AWWA Secretary Harry Jordan informed the group of the activities of the national association in the past few years. Section Secretary-Treasurer A. W. Clarkson read a report of the various activities during the past year.

Committee reports were presented by H. B. Foote for the Dean Cobleigh Memorial Committee and the Montana Health Council, and by C. W. Brinck for the Water Works and Sewage Works School Committee.

Gerald Arnold, director of the Water Resources Div., National Production Authority, Washington, D.C., gave an interesting address on critical materials and gave the group the latest priorities information on water supply materials and equipment.

John B. Hazen, superintendent of the Butte Water Co., delivered an address on electronic controls for chlorination. He had recently developed such a system for one portion of the Butte water supply. At the time he started work on this device, there was no equipment on the market that would treat the great variations in water flow that exist at this source of supply. The system described works on electrical impulses delivered to an electronic device which in turn regulates the speed of direct current motors

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operating the pumps. The pumps in turn introduce a standard strength chlorine solution into the water supply.

F. A. Grasier, utility officer, Regional Office, F.C.D.A., Seattle, Washington, informed the group of civilian defense activities in the Pacific Northwest with special reference to the protection of public utilities, especially water supplies. He urged communities to be fully prepared for any emergency. Should a catastrophe occur, the chain of command would lead from the city to county, to the state, to the regional defense office. In general the community will be required to supervise most of the activities on the local level. The local personnel are the ones who are best acquainted with local conditions and insofar as possible they should try to control the situation to avoid confusion. But if they should need help, the higher echelons will be available to give what assistance they can.

Secretary Jordan spoke about current decisions on a national resources policy. He reviewed the legislative report of the President's Water Resources Policy Commission, which urged the appointment of fifteen river basin commissions under a five-man board of review. He also traced the history of our national water resources policy and cited many disappointments over the years as various groups and boards have studied the prob-

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lems and issued voluminous reports, but failed to receive political action on their proposals.

A panel discussion on stream pollution was conducted during the meeting. The members of the panel were Glen Hopkins, officer in charge of the Missouri River Drainage Basin Office, U. S. Public Health Service, Kansas City, Mo.; Robert E. Stafford, Pacific Northwest Drainage Basin Office, U.S. Public Health Service, Portland, Ore.; C. W. Brinck, director, Div. of Environmental Sanitation, State Board of Health, Helena, Mont.; H. B. Foote, State Board of Health, Helena; F. F. Palmer, city engineer of Forsyth, Mont.; and Richard Setterstrom, industrial engineer, Montana Power Co., Butte, Mont.

Glen Hopkins and Robert E. Stafford discussed pollution of the upper Missouri, Clark Fork, and Kootenai Rivers. In the Upper Missouri River drainage basin area of Montana 34 of 76 communities have adequate sewage treatment facilities, 14 have inadequate facilities and 28 have no treatment whatsoever. There are 20 industries in which abatement projects are needed. The Clark Fork and Kootenai River basins are part of the Pacific Northwest basin and include an area of 140,000 people. At the present time 90 per cent of sewage load of this area flows into the rivers without treatment.

C. W. Brinck stated that there has been much improvement in existing legislation on stream pollution abatement, but much remains to be done. At present municipalities cannot extend sewer systems without providing proper treatment facilities. New industries must present plans for control of their wastes for approval by the State Board of Health.

H. B. Foote discussed a model stream pollution law for the state of Montana. This law was prepared over a year ago but no action has been taken on it to date, largely because no group has been interested in doing so. This bill would establish a policy that the state protect, improve, and maintain the qualities of the water in the state as they affect legitimate uses of pure water, including agriculture, recreation, livestock, fish and wildlife, and municipalities. Such a law would create a water pollution council of nine medical and lay members within the Board of Health. The Board of Health would administer the law which provides powers, duties, and penalties for violations going far beyond its present powers.

Richard Setterstrom agreed that there must be controls on industrial wastes. He firmly believes that it is much easier to get the necessary waste disposal constructed in the original building rather than to have it built after the company has developed.

F. F. Palmer stated that industries must not be permitted to spoil our natural resources. Our water plants should be so designed as to treat all natural pollutions, but there are some industrial wastes that cannot be treated

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at the water plant without the expenditure of a great deal of funds, and industries should be required to control such wastes. He proposed a resolution that a legislative committee be formed in the section to introduce a pollution control law at the next session of the legislature.

A round table discussion was led by Arthur Johnson on the payment by municipalities for the relocation of service lines made necessary by federal highway changes. All seemed to think it unfair for the federal highway development to require the towns to carry this additional expense. It was proposed that the cost of the relocation of service lines be prorated between the highway departments and the utility owner.

The topic of fluoridation of public water supplies was also discussed, and M. E. Snell of Roundup—the first community in Montana to add fluoride to the public water supply—began the session. M. E. Henderson of Bozeman charged that the proponents of fluoridation are issuing half truths and misleading statements, arguing that the publicized cost of from 5¢ to 14¢ per person per year does not apply to Montana cities, in many of which the water usage is in excess of 500 gpcd.

The last topic discussed at the Round Table was the effect of the development of a pulp wood industry in Montana on the public water supplies derived from streams and rivers.

One of the highlights of the meeting was a conducted tour of the Continental Oil Co. plant, the municipal water treatment plant, and the new Montana Power Steam Plant, all in the Billings area.

The meeting concluded with a banquet and dance at which a 25-year award was given to D. Thomas of the National Fire Underwriters of the Pacific, Great Falls, Mont.

John W. Hall, a consulting engineer from Fort Shaw, and one of the founders of the section, was nominated to receive the George Warren Fuller Award. He has devoted his life to the promotion of public works in the state.

A. W. Clarkson,
Secretary-Treasurer

New York Section: The annual spring meeting of the New York Section was held at the Hotel Syracuse, Syracuse, on Thursday and Friday, April 17 and 18, 1952. An inspection trip was made of the New York Water Service Corp. plant in Syracuse and also of several industrial plants.

The meeting officially opened on Thursday noon, with the usual luncheon and address of welcome by Mayor Thomas J. Corcoran of Syracuse. "Priorities and Materials" were discussed by Roy O. Van Meter, special assistant to the director of the Water Resources Div., National Production Authority, Washington, D.C. "New Developments in Civil Defense

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and Mutual Aid" was presented by Charles R. Cox, chief of the Water Supply Section, Bureau of Environmental Sanitation, State Dept. of Health, Albany, representing Earl Devendorf, director of the department, who could not be present at this meeting.

"Water Authorities—Pro and Con" was presented by Alexander Russell, executive secretary of the Monroe County Water Authority, Rochester, who discussed the subject of water authorities as they are developed in New York State. "The Training of Water Works Operators" was discussed quite fully by William T. Ingram, associate professor of public health engineering at New York University, where water works regional schools are held each year for Grade 2 Operators.

The Cocktail Hour, held through the courtesy of the Water and Sewage Works Manufacturers Assn., has become an annual feature of the New York section meetings and has worked out particularly well because it affords so many of the newer members an opportunity to meet with the older members and become acquainted with them, as well as to discuss common problems.

The annual banquet was held in the Ball Room of the Hotel Syracuse, and the principal speaker was Charles H. Capen, president-elect of AWWA.

The Round Table Conference on Friday provided an excellent opportunity for all to voice their opinions on the four main topics of discussion: water dowsing, corrosion control from the standpoint of small supplies having no filtration plants, laboratory control of fluoridation treatment, and development of springs for increased yield.

As a result of the annual elections, John G. Copley of Elmira became chairman; Thomas B. Tyldesley of Watertown, vice-chairman; R. K. Blanchard of New York, secretary-treasurer; and Frank D. Behan of Plattsburg, trustee. Robert W. Austin of Albany became the new past-chairman. Wallace T. Miller, general manager of the New York Water Service Corp., Rochester, was selected to receive the section's Fuller Award for the current year.

R. K. BLANCHARD
Secretary-Treasurer

Coming Meetings

June **18–20**—Pennsylvania Section at Lawrence Hotel, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

25—New Jersey Section Summer Outing. Luncheon at Martinsville Inn, Martinsville. Inspection of Elizabethtown's Millstone-Raritan Filter Plant.

September 3–5—New York Section at Saranac Inn, Upper Saranac Lake. Secretary, R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.

10–12—Minnesota Section in Sioux Falls, S.D. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

15–17—Kentucky-Tennessee Section at Andrew Johnson Hotel, Knoxville. Secretary, R. P. Farrell, Director, Div. of San. Eng., Tenn. Dept. of Pub. Health, 420 6th Ave., N., Nashville 3, Tenn.

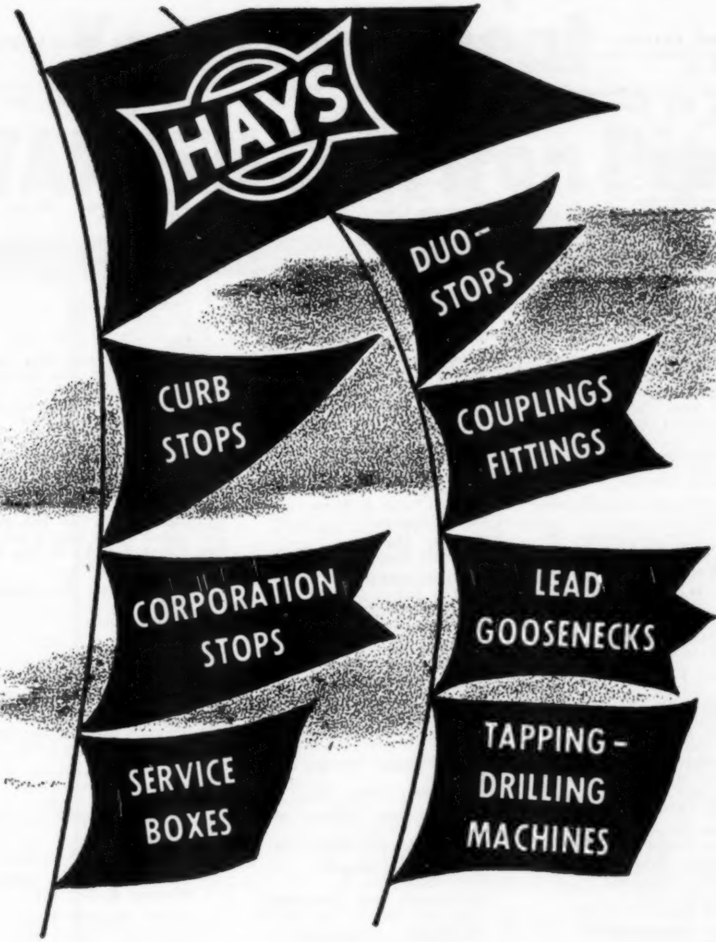
16–17—Rocky Mountain Section at Frontier Hotel, Cheyenne. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

16–18—Wisconsin Section at Hotel Loraine, Madison. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3, Wis.

18–19—Ohio Section at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington, Ohio.

21–23—Missouri Section at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

24–26—Michigan Section at Post Tavern, Battle Creek. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing, Mich.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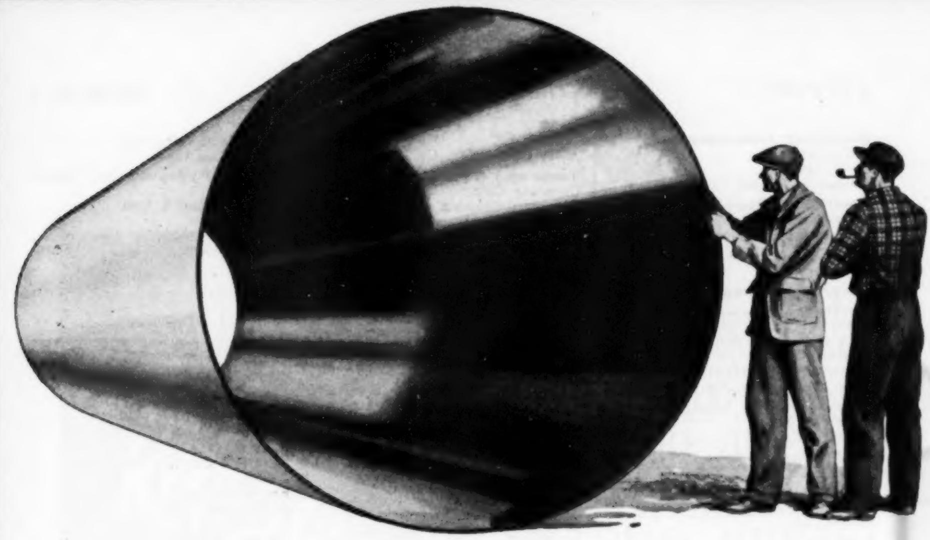

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